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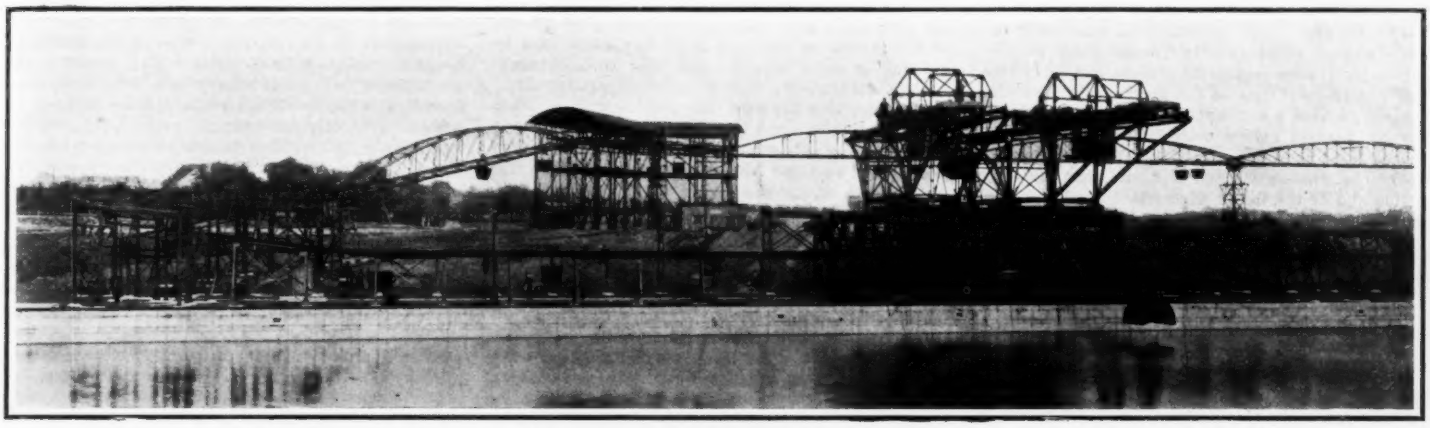
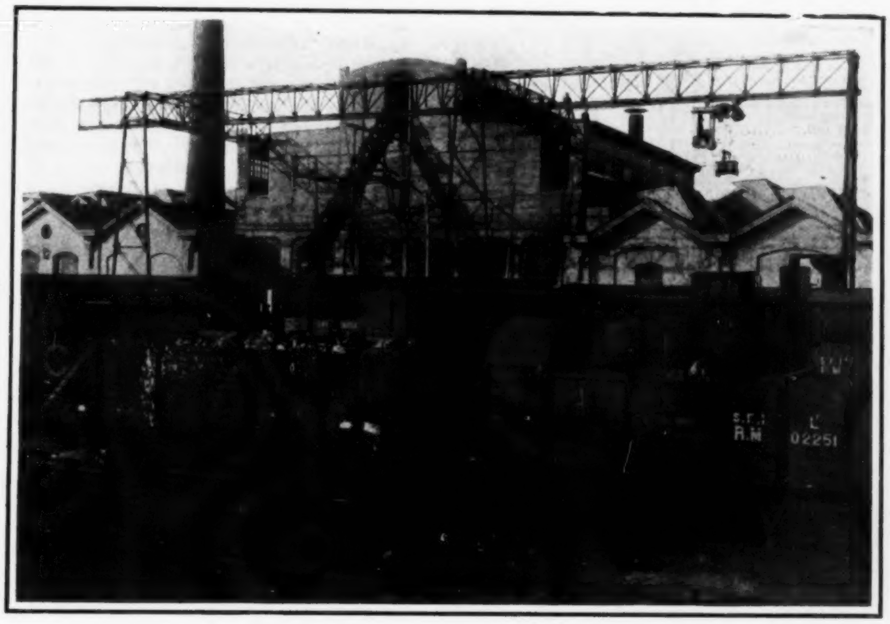
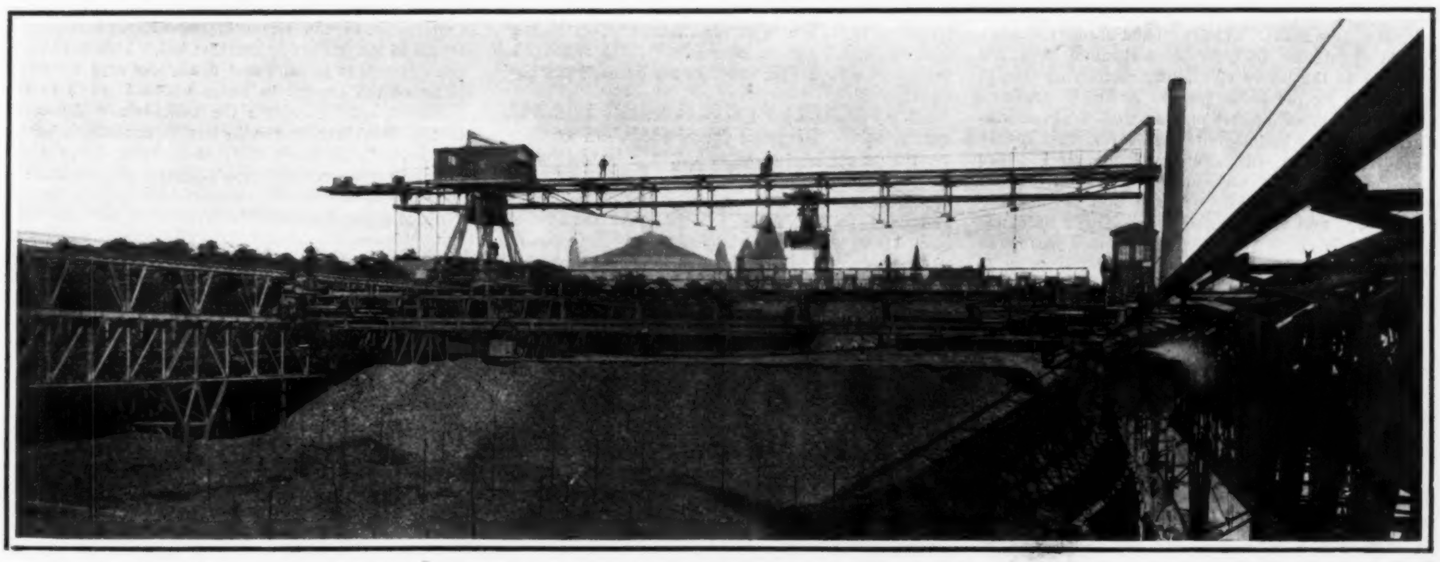


COAL-HANDLING PLANT ON THE TELTOW CANAL.

LOADING CARS AT STATION.



COAL-CARRYING PLANT FOR LOADING RAILROAD CARS.



THE COKE-STACKING YARD AT THE BERLIN MUNICIPAL GAS WORKS, SHOWING TRANSVERSE BRIDGES OVER WHICH CARS PASS TO SHOOT CONTENTS, AND THE HIGHER BRIDGES WITH GRABS FOR RELOADING COKE.

LOADING AND CONVEYING PLANTS IN GERMAN GAS WORKS.—[SEE PAGE 40.]

# HARDENING HYDRAULIC CEMENTS.—II.*

## A DESCRIPTION OF A NEW PROCESS.

BY DR. W. MICHAELIS, SR.

Concluded from Supplement No. 1723, page 32.

WHEN will the time come when we shall learn to produce elaborately worked-out and highly-finished ornamental blocks, and when we shall attain what I conceived from the beginning? Of course molding machinery different from our common brick presses has to be devised for this purpose.

This identical stone I showed in a lecture thirty-three years ago. (The artificial stone referred to is a highly finished 6-foot lintel in Grecian design.)

Recently I have broken off a piece and have carefully analyzed it. Outside and inside could have been expected to have a different composition. The center may still contain sodium chloride, although the stone never showed efflorescence of salt. Therefore, an average of the whole piece and separate samples of the outside and of the inside were tested for loss at red heat, carbonic acid, and chlorine.

| | Average of the whole piece. P.C. | Outside. P.C. | Inside. P.C. |
|---|---|---|---|
| Chlorine ........ | trace | trace | trace |
| Water ........... | 1.082 | 1.315 | 0.758 |
| Carbonic acid.... | 3.617 | 3.665 | 3.573 |

The complete analysis of the stone showed the following composition:

Artificial Sandstone Manufactured in 1873 Under Ransome's Process by Julius Erichsen, Saltholm, Copenhagen.

| | 1907: Per Cent | 1873: | 1907: |
|---|---|---|---|
| Soluble silica............ = | 4.794 | $SiO_2 = 4.794$ | $4.794 + 0.720\ H_2O$ |
| Iron oxide plus alumina . = | 0.296 | $R_2O_3 = 0.296$ | $0.296 + 0.121\ H_2O$ |
| Calcium oxide ........... = | 4.601 | $CaO = 4.601$ | $4.601 + 3.615\ CO_2$ |
| Calcium sulphate.... .. = | 0.105 | $H_2O = 3.000$ | |
| Magnesia ........ ... = | 0.047 | 12.690 | 14,146 |
| Sodium chloride.... .... = | 0.153 | | |
| Carbonic acid ........... = | 3.505 | | |
| Water.... ............ = | 1.141 | | |
| Quartz sand...... ....... = | 85.556 | $SiO_2.CaO + aq$ | $2SiO_2 + 1H_2O$ and $CaCO_3$. |
| | 100.287 | | |

In 1907 the dry inside absorbed 13.2 per cent of water, determined by boiling and cooling in water. When made thirty-three years ago it was impervious to water; at that time all voids were filled by the hydrogel $SiO_2CaO + aq$. Hence the stone became porous by drying out and by gradual decomposition of the calcium hydro-silicate.

The result of the chemical investigation is that the inside and outside of the stone prove to have the same composition. Consequently the carbonic acid of the atmosphere has entered the inside. Furthermore, the analysis shows that the stone had been washed out completely, for it contains only 0.153 per cent of sodium chloride. Moreover, we learn from it that the mono-calcium hydro-silicate has been completely decomposed by the carbonic acid of the atmosphere, and has formed silica half-hydrate and carbonate of lime.

(Everyone who has doubted whether or not hydraulic cements can form stable compounds may see in this the best proof for the fact that all of them are completely decomposed by carbonic acid, whenever and wherever this latter can act upon a cement. Another lesson we learn from this is that sand-lime brick must not be laid with lime-mortar, but with cement or cement-lime mortar, which sets and hardens without the aid of carbonic acid, for the carbonic acid cannot penetrate to the layers of binding mortar, because it is absorbed by the brick itself.) A higher grade of stone and a more durable one, so free of all efflorescence, can hardly be imagined. Moreover, what should cause efflorescence with a stone containing 85.5 per cent quartz sand, 5.5 per cent silica hydrate, 8.2 per cent calcium carbonate, 0.3 per cent iron and alumina hydroxide? And last but not least consider its extraordinary strength! We have to regard this product as an ideal artificial sand-stone.

If you make the most rational use of the highest grade of Portland cement, that is to say, if you grind it with twice as much quartz sand to a very fine powder, and then mix it with seven parts of coarse quartz sand, you can never attain a stone of so high a strength and this is easily explained. So intimate a mixture of sand and cement as in Ransome's process can never be attained, not even with the most finely pulverized substances obtainable in practice.

The preceding information is one of the proofs for the correctness of my statement that only silica, lime, and water are necessary for the production of a perfect hydraulic cement, and that this calcium hydro-silicate is a hardened colloid.

I now shall describe to you a very ingenious invention based upon my interpretation of the nature and the properties of hydraulic cements. The invention consists in treating Portland cement like rags in the beater and on the calender. You would naturally be surprised to see a man try to treat Portland cement like paper pulp, and you would question his conception of the properties of cement, and yet he merely makes use of what I have taught about hydraulic cements at the Stockholm Congress in 1897, namely, that by swelling in water they increase their volume twenty times and even more, and are transformed into a flocculent gelatinous substance. In order to briefly illustrate this swelling and to recall it to your memory, I show you the result of continuous agitation of 15 grammes of Portland cement and 15 grammes of slag cement with 40 times as much water. In the beginning of this experiment the whole flask was filled with flakes of a colloid. Since then five years have passed; during this time the colloid has contracted and hardened under water, and yet you observe that the volume of the colloid is still from 20 to 25 times that of the original cement.

In the same manner the inventor continuously stirs and agitates two pounds of cement with 50 quarts of water, and obtains a dough which he transfers to a fine sieve and which he treats in the same manner as hand-made paper is manufactured. Then he presses out all surplus water by means of a press, and lets the plate dry very gradually. The slab grows harder and denser in time, and finally has the properties and appearance of slate. I suppose you would like to see such a slab. Here it is. I have to add that the inventor has worked from 10 to 20 per cent of asbestos fiber into his product in order to obtain complete intertwining and in order to decrease the brittleness of cement as much as possible. This artificial slate or cement board containing from 80 to 90 per cent of neat cement is called "eternite" (everlasting); it is manufactured by beater and calender in the same way as card-board. The name is very pretentious, but the inventor is right in giving it this name, for people are nowadays so accustomed to being promised ten times beyond what can be performed for fear an article, no matter how perfect, will not become conspicuous; strange but true nowadays more than ever, the people like to be humbugged. Fortunately the properties of eternite are not exaggerated; this is a splendid invention indeed, an excellent application of the deductions from my research work. However, we do not build for eternity; no sensible person demands this, and the least of all the manufacturer.

The last described invention was the second practical example of my "gel-theory."

The knowledge of the foregoing will enable you to understand and to appreciate my deductions.

I beg you once more to look at these swelled hydraulic cements which I used as illustrations ten years ago at the Stockholm Congress. In the first place the swelled silica, then the quartz powder which has been made to swell by lime water on a water bath at about 100 deg. C., and which represents the cementing material in sand-lime brick, furthermore swelled trass, santorin earth, Roman cement, Portland cement, hydraulic lime from Teil, and here the formerly discussed melilite.

Let me repeat what I said about these swelled substances in the beginning of my paper. In metaphysics this state of matter is called a submicroscopic foam; chemists designate it as a gelatinous substance, as a colloid. We know more or less liquid colloids and even solid colloids. Only liquid foam-lamellæ have cell walls which make osmotic diffusion possible, and which can swell and permit of unhindered exchange of substances, that is to say, of complete reactions. Solidified colloids, the walls of which have been transformed into solids, are an obstacle to the free exchange of liquids, make reactions difficult, and finally with increasing hardening become perfectly impervious to liquids. Silica in the form of flint is the best example of a completely impenetrable hardened colloid.

Upon the existence of the hardening and solidifying colloids, created during the hardening process of all calcareous hydraulic cements, depends their durability in water; the formation of a solidified colloid as the chief element of the hydraulic cements is the characteristic and the only essential feature of the hydraulic hardening process. Whenever free silica or silica partly uncombined, as is the case in puzzuolanas and slags, comes in contact with lime (calcium oxide) and water, or when water acts upon silica oversaturated with lime, as in Portland cement, colloids are formed, and it is of no consequence whether there are 1, 2, 3, 4, 5 or 6 molecules of calcium oxide present for each 4 molecules of silica; in all cases colloidal calcium hydro-silicate is formed. The amount of lime surpassing 6 molecules of calcium oxide is in the beginning enveloped in the colloids, as colloidal calcium polyhydrate, but mostly crystallizes later as calcium-monohydrate. The more lime combines with the silica, the more firmly the colloids solidify as a rule. Any modification of silica forms calcium hydro-silicate when in contact with calcium hydrate, even quartzy silica, which latter, as you know, has to be heated to over 90 deg. C. in order to facilitate the reaction. Iron oxide and to some extent also alumina act in a similar way, but are not necessarily required for the formation of a hydraulic cement; calcium oxide, silica and water suffice for this purpose.

Every neat cement briquette when perfectly hardened shows how thoroughly impervious the colloidal ground mass is which is composed of the hardened calcium hydro-silicate, calcium hydro-aluminate and calcium hydro-ferrite. The briquette, which may have been kept in water for years, shows on breaking an absolutely dry light-colored core surrounded by a dark moist zone. This difference between damp outside and dry inside is to be explained by the action of the carbonic acid on the cement. The carbonic acid penetrates from the outside into the hardened colloid, decomposes the calcium hydro-compounds and forms calcium carbonate in them, whereby it expels a certain amount of water. Rhombic calcspar crystals interrupt the cohesion of the formerly dense colloid, and thus form submicroscopic fissures between the separating walls of colloid and crystals, which permit the water to penetrate into the mortar.

As another very instructive example of the impermeability of hardened hydro-silicates I should like to mention the following: If you tamp into a capsule of filter paper of a diameter of 2 centimeters a mixture of 2 parts of finely pulverized trass and 5 parts of standard sand, seal it and hang it into permanently saturated lime-water, you will never obtain more than a hardened filter paper shell; a thin hard crust (about 1 millimeter thick) is formed comparable with an egg shell. Immediately after immersion of the capsule into the solution a small amount of lime-water penetrates into the capsule, but beyond this not a trace of lime reaches the powdered trass. No matter how long you may wait, you will always find inside of the capsule a mass without any cohesion whatever, and water absolutely free from lime filling the interstices of the mixture.

From experience you know that the hydraulic hardening process is always more or less accompanied by a process of crystallization. The formation of crystals, however, is of minor importance, it is inconsequential, and considering it as a whole it is more of a detriment.

As a matter of fact, the formation of crystals greatly contributes to the strength, especially in the later stages of the hardening process; but, which is of more consequence, it impairs and finally destroys the durability of the cement in water which it owes to the hardened colloid. Hence the colloids are the cause of the durability of the hydraulic cements, whereas the crystalloids work their destruction. The more elaborate the process of crystallization in cements, the sooner they are doomed to deterioration.

As previously stated, the separating walls between the hardened colloid and the crystals permit access to the liquids, which means ultimate destruction. Even in the presence of pure water chemical reaction sets in immediately; lime, gypsum and aluminate go into solution and act one upon another. But if the percolating liquid is charged with salts, for instance if sulphate solutions or sea water or acidous water enter into play, very energetic reactions go on. The formerly submicroscopic interstices widen to microscopic fissures and these grow in course of time to macroscopic cracks and crevices; at first hair cracks are formed, and by and by large rents. The formation of crystals, which is accompanied by increase of volume, ultimately with irresistible power causes the mortar to burst more or less completely. Or, on the contrary, the lime is gradually dissolved and carried off and only softened hydrates of silica, iron oxide and alumina remain instead of the original rock-like hardened colloid.

* Abstracted from a paper read before the Association of German Portland Cement Manufacturers at Berlin, Germany.

Therefore, the possibility of access of solutions includes unavoidable deterioration. There are some variations or exceptions to this rule; thus colloids may be formed besides crystalloids in the course of the reactions caused by entering solutions. This may delay ultimate destruction or make it even temporarily impossible. As an example of this phenomenon I mention the formation of magnesium hydroxide caused by the action of sea water. Furthermore I must mention that carbonic acid acts in two ways: it becomes injurious by its separating the cohesion of the hardened colloid, and becomes beneficial by making the lime insoluble or difficult to dissolve. From the foregoing you see that very complicated processes may take place. But all the phenomena we may observe are easily reduced to and found to be based upon the following two processes:

1. Formation of a colloidal fundamental substance composed of calcium hydro-silicates, calcium hydro-aluminates and calcium hydro-ferrites which forms the characteristic and the essential part of all hydraulic cements, and is the cause of their hydraulicity, and

2. Formation of crystalloids, as, for instance, calcium aluminates, calcium sulphate, calcium and magnesium carbonate, and calcium sulpho-aluminates, which as a rule increase, even sometimes considerably increase, the strength of the ground mass in which they are imbedded, but which at the same time cause formation of cracks within the hardened colloids, thus admitting solutions and leading to destruction; or, in other words, existence of processes of crystallization, which are the cause of instability and short life of the hydraulic cements. I hope and trust cement experts will in the future try to comprehend and entertain and fathom my views, which they have not done heretofore.

The conclusions to be drawn from the foregoing with reference to practical application must be the following: Hydraulic cements will be the more reliable and the more durable the more limited the process of crystallization during their hardening; hence hydraulic cements low in alumina and lime are the most preferable. The surplus of lime crystallizes, precipitates crystals of gypsum from gypsum solutions and favors formation of calcium sulpho-aluminate in the presence of aluminates and sulphates; or the surplus of lime is dissolved and carried off, and in consequence the cement becomes porous. The alumina, on the other hand, forms unstable crystals of calcium aluminate, and in presence of sulphate solutions the dreaded calcium sulpho-aluminates.

To the group of hydraulic cements low in lime belong the Roman or natural cements, slag cements, and puzzuolana cements. They have, however, this disadvantage that they are very incompact and consequently form colloids which are less dense, which therefore greatly increase their volumes by swelling, and which for the same reason shrink considerably on drying. A further drawback is their high percentage of unstable aluminates. To the cements low in alumina belong the siliceous hydraulic limes, for instance, the famous hydraulic lime from Teil, the grappler cement and the iron-ore cement; these however, are all high in lime.

Iron-ore cement is, as a matter of fact, an ideal hydraulic cement, because its calcium ferrites never crystallize, and possess, if vitrified, wonderful resistance under all circumstances. Moreover, iron-ore cement belongs to the strongest cements and yields the densest mortars, for it has the highest specific gravity of all Portland cements; its density is 3.3 to 3.4. A large cement company manufactures this new cement with only about 1 per cent of alumina; but its use has been rather limited so far, evidently on account of insufficient advertising.

As valuable as the properties of the colloids may be, if the cement is used in water, where its durability can only be impaired by formation of crystalloids, I am not allowed to leave unmentioned that the colloids do not behave equally well in cements exposed to air. In this case the cohesion of the colloids is gradually impaired by drying out, which causes shrinkage cracks, for, as well as colloids swell in contact with water, they dry out, contract, and shrink in air. Such shrinking is accompanied by loss of water.

All of you will have observed that sometimes years pass before shrinkage cracks become visible in cement sidewalks or floors, and that these widen and increase in number from year to year. This serves to demonstrate how slowly the colloidal ground mass loses its water. The only way to counteract the shrinkage process in cements exposed to air is, besides using lean mortars, to gage the mortar with as little water as practically possible.

It will certainly require some study yet in order to explain all features that can be observed with hydraulic cements; but, in my opinion, the characteristic and essential part of the hardening process has been revealed herewith; I really can no longer see anything obscure.

After having listened to the foregoing no one will be able to contend that the same cement which results in a hard stone, when gaged with little water and left to rest forms a colloid, a hydrogel when stirred with much water and when kept in agitation, and that the formation of the hydrogel is a characteristic property of cement. Furthermore no one can contend that the colloids of Portland cement and of slag cement, which I showed you by expelling of all swelling water, can be transformed into a stone as you have seen in the form of the eternite slab, or that this artificial slate has originated from colloidal Portland or slag cement. The compression strength of the hydrogel amounts to next to nothing, but that of the stone obtained from it by compression is as high as 15,000 pounds per square inch. These facts are indisputable.

The deduction which necessarily follows from this is that the hardening of all hydraulic cements is mainly based upon the formation of a gel and that the hardness and resistance of the gel, if we do not consider the process of crystallization, depend upon the solidification of the gel particles and upon the original density of the cement.

Now, if you please, in what can my deductions be faulty?

That it required 150 years, if I go back as far as to Smeaton's experiments, in order to rightly comprehend the hardening process, is to be explained by the fact that formerly the existence and behavior of colloids were rather unknown and that our knowledge of colloids is even now still in its infancy. Investigators invariably approached this subject with the assumption that the reactions go on according to well-defined stoicheiometrical proportions, that the elements always combine in integral parts, and that this problem can be solved without leaving a remainder; but the varying composition of the colloidal calcium hydro-compounds is in contrast to that; there were always remainders left; to-day reactions went one way and to-morrow another, and in order to mention only an apparently quite insignificant factor, experimenters used too coarsely ground substances. If you try to make subtle reagents act upon grains so big that they just pass a 200-mesh sieve you cannot expect correct results, because the core of so large a grain will be imbedded in hardening colloids which form on its surface, and which are almost or even entirely impervious. Therefore the inside of the grains will not be reached by the reagents and will remain unchanged, it may be forever, but at least for a very long period. The experiment, therefore, must result in failure.

## SCIENTIFIC BOILER CONTROL.

AT the Institute of Marine Engineers, Stratford, a lecture was given by Mr. G. A. H. Binz on "Scientific Boiler Control." After remarking upon the large amount of waste, even with experienced firemen, due to the usual methods of stoking, Mr. Binz advocated as a remedy a continuous and automatic analysis of the products of combustion which would indicate the method of stoking that produced the best results. The carbon in the coal, he said, was not always burned to $CO_2$; it might be changed only to CO, or any particle of $CO_2$ might be retransformed into CO if it should, in its passage through the firebed and flues to the chimney, come into contact with atoms of highly-heated carbon. The proportion in which these two gases were present in the furnace gases could only be determined by chemical analysis. A pound of dry carbon burnt entirely to $CO_2$ gave heat equal to 14,600 B.T.U., whereas the same weight of the same carbon burned to CO only yielded 4,450 B.T.U. It, therefore, followed that if there were a low percentage of $CO_2$ in the exit gases a lot of the heat was lost, and, inversely, a high percentage of $CO_2$ denoted good combustion. This percentage could be ascertained by means of a $CO_2$ recorder, an instrument which produced, practically automatically, a certain number of records per hour of at least one of the products of combustion. There were two factors to be considered in estimating the $CO_2$ contents of the exit gases—the presence of CO when the percentage of $CO_2$ was high, and the temperature of the gases at the stack. As CO was a heat absorber, it was obvious that it would be of little use to produce a set of conditions which, while securing a high percentage of $CO_2$, also had a tendency to encourage the presence of CO in appreciable quantities, but the admission of air was all that was necessary to prevent this initial formation. The possibility of the transformation of $CO_2$ back to CO was very remote as long as the percentage of $CO_2$, as shown by the recording instrument, was not more than 14 to 15 per cent, and the formation of CO under those conditions was most probably due to a low velocity of the gases in the furnace at a high temperature, which encouraged contact of particles of $CO_2$ with highly-heated carbon. A high temperature at the stack was due either to conditions unfavorable to complete combustion of the fuel and the gases given off by it immediately over the grate, or too high a draft pressure. The results in the former case would be shown on the recorder, but in the latter case it was advisable to take into consideration the temperature of the exit gases in addition to the percentage of $CO_2$. If an engineer could, by the use of a $CO_2$ recorder, increase the percentage of $CO_2$ in the exit gases from 5 to 14 per cent, it would effect a saving in coal of 21½ per cent, and if, in addition, he succeeded in reducing the temperature at the stack by 100 deg. the saving would amount to 24 per cent. A "Sarco" $CO_2$ recorder was afterward exhibited, and the lecturer explained its working and construction. In reply to questions, the lecturer said the machine was mainly used on land installations, but instruments had recently been perfected with special fittings for marine work. Where there was a series of boilers the pipes conveying the gases for analyses were connected up from the different boilers so that an average could be taken for the series. In a multitubular boiler the gases were taken either from the combustion chamber or the front of the boiler as preferred. The recorded results from the combustion of oil fuel were not so good as those from coal. The opinion was given that, as the samples were taken out at intervals, a record might be obtained which would not be representative, as the samples might be taken on successive occasions when the doors were opened for firing, but the lecturer stated that this effect would not be experienced when an average was taken. It was also held that, although the recorder showed a worse record of consumption for oil fuel than for coal, it did not necessarily prove the latter to be more economical, as there were differences in the processes of combustion between the two fuels, which might not be shown on the recorder. It was proposed that the lecturer be asked to give a demonstration with the "Sarco" recorder in the experimental room of the Institute.

## DIFFERENT METHODS OF IMPACT TESTING ON NOTCHED BARS.

SO MANY methods of testing steel by impact have been suggested by engineers during the last few years that it has become a matter of importance to investigate the value of these tests as compared with the ordinary tensile tests which in the past it has been customary to rely upon largely, and also to compare the best-known methods of impact testing with each other to see which gives the most concordant results. At a recent meeting of the Institution of Mechanical Engineers Mr. F. W. Harbord described a series of experiments undertaken by him with the object of (1) comparing the results obtained by different methods of impact testing; (2) seeing whether such tests detected any irregularity in steel not revealed by the ordinary tensile tests, and to what extent they were in agreement with the latter.

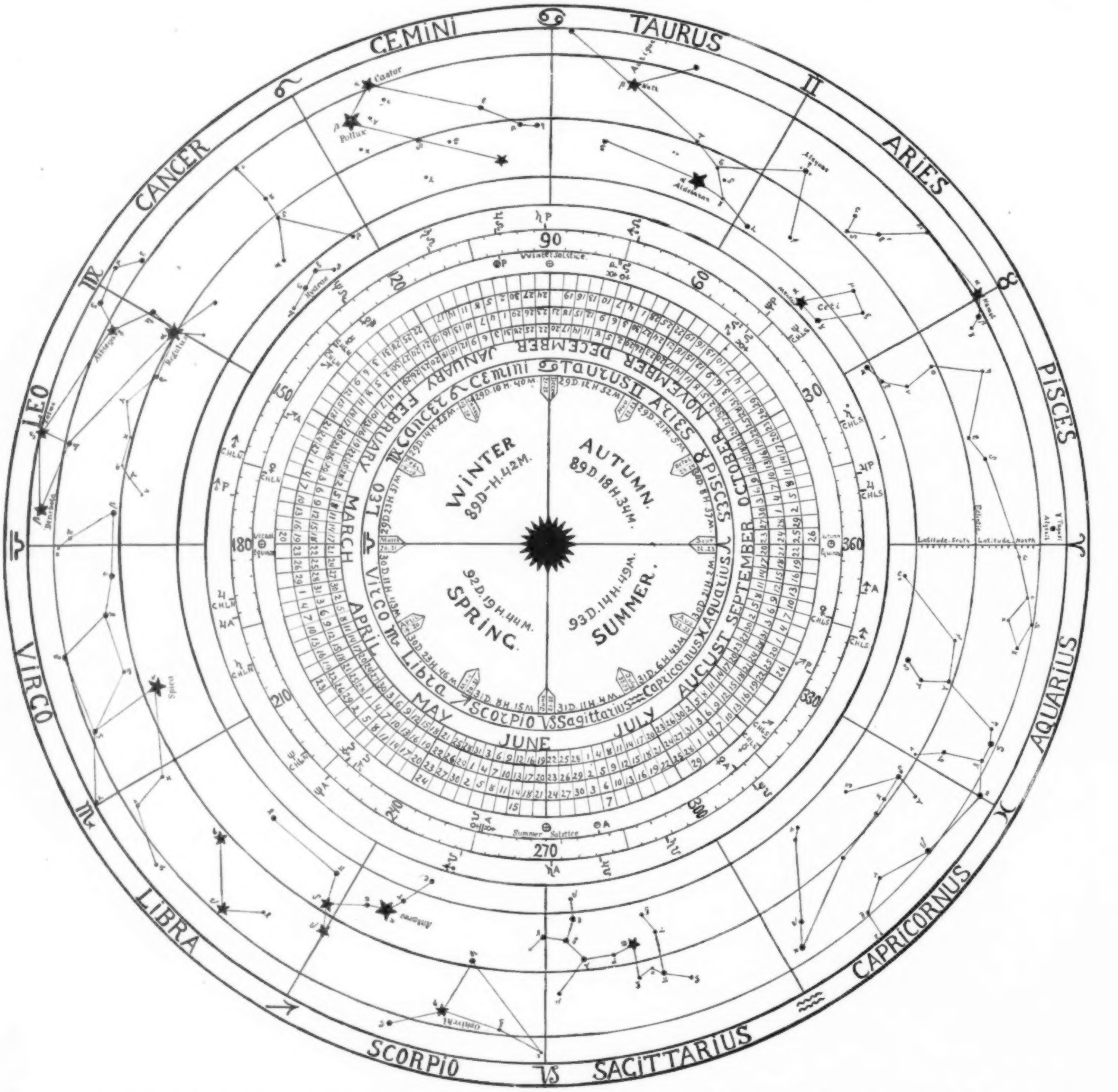
The methods of impact testing were too numerous to allow of all of them being experimented with, but broadly the methods may be divided into four or five classes as follows: (1) One notch in the center of the bar; two supports; fracture effected by a series of blows of a falling weight (Seaton and Jude). (2) One notch in the center of the bar; two supports; fracture effected by one blow of a falling weight (Fremont). (3) One notch not necessarily in the center; one support; fracture effected by one blow on overhung portion from a falling pendulum or weight (Izod). (4) Two opposite notches not necessarily in the center; one support; fracture effected by a series of blows of a falling weight on overhung portion (Brinell). (5) Same as (4), but with an arrangement for reversing the bar after every blow (Kirkaldy). Over 800 bars were prepared and tested, the detailed results of each being given in the paper. It appears that much irregularity was disclosed by the different methods of impact testing, but the author believes that this is not due to lack of uniformity in the material, but largely, at all events, results from the defects of the method of testing, and it is a serious question how far methods showing such variations should be relied upon by engineers to differentiate between the physical properties of different materials.

Taking the results as a whole, the Kirkaldy methods and Izod method gave results more in accordance with the tensile tests, and also showed less variations generally in the duplicate tests, but some of the results obtained by these methods varied so much that their value seems very doubtful.

The claim of the supporters of impact testing is that it indicates certain latent defects not shown under a static test, and therefore it is unfair to condemn impact results when they do not agree with the tensile tests. To some extent this is true, and if experiments had shown that duplicate tests might be relied upon to agree with each other within reasonable limits and the results were in general agreement with experience this contention would carry much weight; when, however, we find tensile tests on two steels show a difference of only about 4 tons with approximately the same elongation, and these results are confirmed by the analysis, and then impact tests of two such steels show by two methods the relative brittleness to be as 100 is to 16 and 100 to 21, while other methods give totally different results, one has very seriously to consider the value of these tests.

# AN IMPROVED PLANETARIUM.

## AN APPARATUS FOR STUDYING THE MOTIONS OF THE PLANETS.




HORIZONTAL DISK OR FOOT. THE VERTICAL AXIS CARRYING THE PLANETS IS MOUNTED IN THE CENTER.

The difficulty of illustrating intelligently the processes resulting from the motions of the planets around the sun in orbits, all more or less inclined to that of the earth—the ecliptic—and the burdensome task cast upon the teacher of making the scholar understand the causes of even the practically daily observed phenomena such as the continual change in length of days and nights, the change of the seasons, the change of the moon's phases, the daily change in rising, culminating and setting of the sun, moon, and stars, etc., are in the first instance the causes of the present gross ignorance of the public in general as to the explanation of the origin of the phenomena.

To render intelligible any explanation of these phenomena, Dr. H. A. Hackeling has designed and constructed the instrument illustrated herewith. The apparatus is now on exhibition at Teachers' College, Columbia University, New York city.

The sun and the planets are represented by special spheres of different sizes within the starry girdle around the celestial sphere called the "zodiacal belt."

At the center of the belt the sun is represented by the largest of the spheres, supported by a central axis, the axis of the ecliptic. Carried by special supporters, which are attached movably around and up and down the central axis, the planets are represented in order of distance from the sun outward.

The sizes of the satellites of the planets, on account of their smallness, are given in the proportion of 6 to 1 as compared with the planets themselves.

The zodiacal belt, that starry girdle around the celestial sphere, which forms the background of our planetary system and the boundaries of which the planets and their satellites never transgress, is represented by a circular band of 20 deg. in breadth.

On its broad side, facing the sun and the planets, the band shows the principal stars of the zodiacal constellations from first to fifth magnitude. The stars composing the single constellations are named and connected by lines.

Midway along the belt is outlined the position of the projected ecliptic, the division of which into 360 degrees is marked on the southern or lower border of the belt, while the northern border shows the signs of the ecliptic and the names of the constellations.

At the equinoctial points of the projected ecliptic there is attached to the belt, at an angle of 23½ deg. to the ecliptic, the celestial equator, represented by a narrow ring. This ring is divided into 24 equal parts, representing the 24 hour circles to illustrate the right ascension and declination of heavenly bodies.

On the outside of the belt, along its circumference, are graphically illustrated in four separate figures: the relative distances of the planets and some asteroids from the sun, the comparative sizes of the planets, the equatorial view of Saturn with its ring system and its moons, showing their relative dimensions and distances from the planet, and the relative sizes and distances of Jupiter from its moons.

The belt, with respect to sun and planets, is kept in proper position by means of four supports, adjustable to the outside of the belt and the lower side of the disk, hereafter to be described.

The planets are carried by supports which are movable around and lengthwise of the ecliptic axis, to the upper end of which the sun is attached. They may be adjusted according to their temporary longitude and latitude on the ecliptic, so that the student is enabled to arrange them on the planetarium in accordance

with the longitude and latitude for any date, and to observe their temporary configurations with respect to each other, the sun, the moon, and the stars in the zodiac.

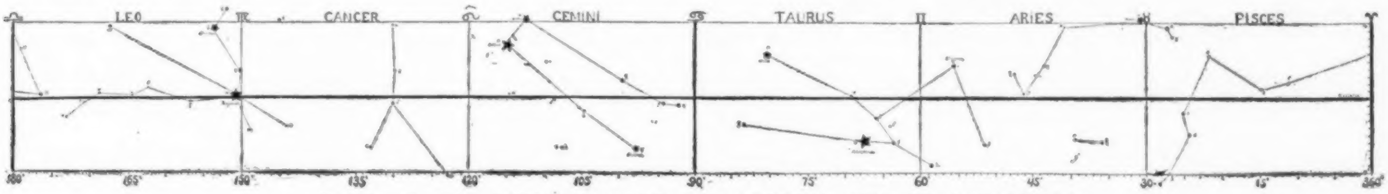
Tables for the determination of the planet's longitude for any date are furnished with each planetarium.

A circular disk supports the whole, and rests on a stand of proper height, exhibiting on its upper surface all the points in the planetary orbits, which have relation to the plane of the ecliptic.

repeating daily and seasonal natural occurrences, as experienced on the surface of the earth.

The apparatus provides anyone with the means to inform himself concerning the measurements on the celestial sphere, the location and motion of the planets and their changing positions relative to each other, the sun and the fixed stars in the zodiacal constellations.

By setting the planets on the planetarium according to their longitude and latitude for the date, the student may convince himself of their temporary configurations and of the nature and inevitability of the resulting phenomena, as seen from the earth. By watching the earth with its invariable axial direction progressing in its orbit, the seasonal changes on its surface, produced by the earth's change of position toward the sun, become at once evident.




PART OF THE ZODIACAL BELT SURROUNDING THE PLANETARIUM.

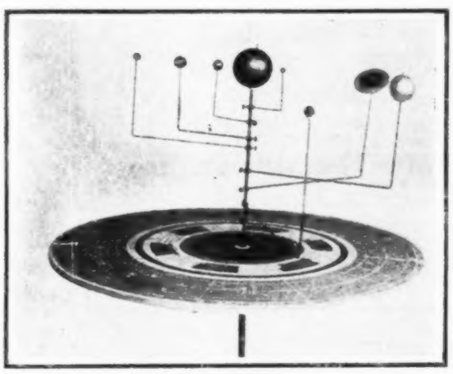
The disk shows at its center the seasons of the year with the seasonal signs in the ecliptic and the constellations of the zodiac, along which the earth moves in its yearly circuit around the sun, and states the dates when it enters a new constellation.

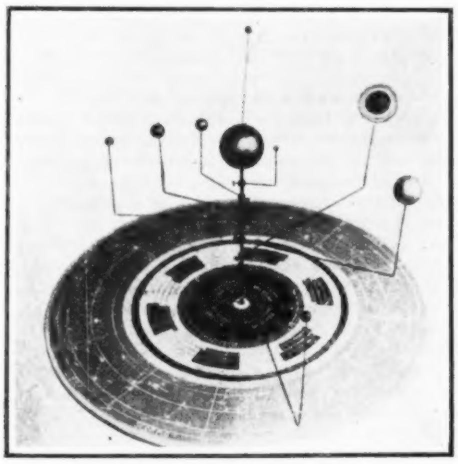
It further shows, in three concentric dials, the months and the dates in the year, the division of the ecliptic into 360 deg., and the constellations of the zodiac with the signs of the ecliptic.

The dates on the first dial, called the calendar dial, correspond to the degrees of ecliptic longitude outlined in the second dial, so that the degrees of longitude point to the date, and the date to the degree of longitude at which the earth has arrived in its journey around the sun.

The longitude dial also indicates the longitude of the orbital points of all the planets and of the equinoctial and solstitial points.

The third and outer dial extends the constellations of the zodiac as given on the zodiacal belt, in that it also represents the most conspicuous stars situated within a zone of 5 deg. north and 5 deg. south of the zodiac proper, of which some are included in zodiacal constellations. The degrees of longitude shown on the face of the disk correspond with the ecliptic longitude as marked on the zodiacal belt. The leading viewpoint taken by the construction of this planetarium was to give, at a merely nominal outlay, the interested public in general, and our public institutions of learning in particular, an apparatus by means of which the pupils in the higher classes may be instructed intelligibly and successfully concerning the natural causes of the celestial phenomena and the regularly





PERSPECTIVE VIEWS OF THE SUN AND PLANETS MOUNTED ON THE VERTICAL AXIS.

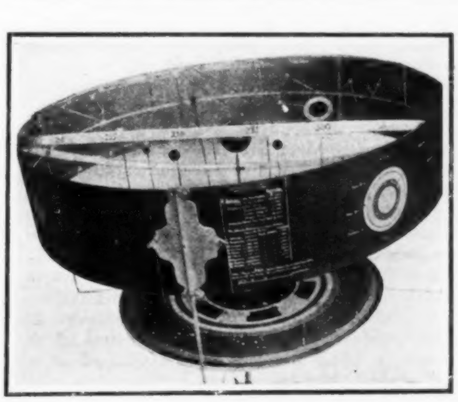
The causes of the change of the moon's phases and of the occurrences of eclipses of the sun and the moon and of planetary transits over the sun may be so intelligibly illustrated that they never will be forgotten.

To demonstrate the relations between cause and effect of these and other phenomena on a larger scale and in a way still more obvious visually, there is provided an extra terrestrial globe, combinable with the moon and horizon ring, with meridian mark adjustable for any place on the earth's surface. Upon adjusting this combination to the planetarium, the other planets should be removed in order to give sufficient room for the demonstration.

In addition, the planetarium may be equipped with an indicator showing the yearly retrograde motion of the moon's nodes, the eclipse years and the eclipse seasons, with the moon's perigee and apogee during one Saros period (1906-1924), which renders it possible to determine the time and degree of a coming eclipse by means of special tables, which are also provided.

## POPPY CULTURE AND OPIUM MANUFACTURE IN INDIA.

Deep plowing is practised for the poppy, which is not the case with any other crop grown in India; the same kind of plow is used now as was in vogue centuries ago. It is a rudely-constructed implement with one handle, a shaft, and the share beam. The last is usually made of the babal tree, because it is tough. A long pointed piece of iron is attached to the share beam to protect the wood, and to enable the plow to sink more deeply into the ground. This plow is drawn by two bullocks. The land is then harrowed, and it is ready for irrigation, which is accomplished by drawing water from a well, with two bullocks, and running it through a sluice to the land. The patch of land, from one-third to two-thirds of an acre, is surrounded by an embankment, which defines the boundary, holds the water for inundation, and serves as pathways. One well can be made to serve twenty to thirty farms of one "beegah," that is, one-third of an acre in extent. There are thousands of these wells throughout India used for irrigation in growing every kind of crop. They are comparatively cheap and convenient, as the farmers dig and equip the wells, and breed the bullocks themselves, so that well irrigation is the cheapest. Moreover, the government can impose no tax for the water, as is done when it is supplied from government tanks or reservoirs, or from canals. There are 25,500,000 acres of land in India irrigated by wells and private irrigation, according to the American Consul-General at Calcutta. The poppy seed is mixed with sand, so that it will not be sown too thickly, and one-third of the mixture is scattered over the prepared ground and the other two-thirds held for future sowing on the same soil. The farmer then gives the ground a watering. When the soil is dried out to some extent, he again plows the land, but not so deeply as at first, harrows, and then sows another third of the mixture of sand and poppy seed, which is treated as the first third. Then follows the sowing of the last third, and similar treatment. Three pounds of poppy seed will sow a "beegah." In a few days the seeds sprout and send up rich green shoots. Then comes the particular work of thinning out the sprouts. To accomplish this, the women and children crawl along much in the same way as is done in weeding and thinning sugar beets. In about thirteen weeks the fields are in a beautiful white bloom, for the white poppy is the one richest in opium, and women and children are set to work gathering the heads. They are carefully packed in baskets, and later made into "roties," which look like bread cakes, eight or ten poppy heads being baked in one cake. The cakes are reduced to powder and afterward mixed with the liquid opium in the factory. When the crop of poppy heads is gathered, work begins in the opium "kothie," which is a shed made of bamboos and thatched with grass. The heads are punctured with four needles, tied in a bundle, and laid aside, for the juice to ooze out during the night. The juice thus obtained is carefully scooped up and preserved in an earthen jar. A poppy head will stand from five to six puncturings, which are made every other day, by which time the head has yielded all the juice that will ooze out. The heads are then broken off and the stalks made into bundles, for both the heads and stalks are sold to the government. After the crop has been thus gathered and put into marketable shape, the government officer comes into the neighborhood, and sends word that he is ready to test, weigh, and pay for the opium produced. The old factory at Patna is one of the largest factories in Bengal, as well as one of the oldest. Here the crude opium is again tested, and then put into large vats which are slightly heated. Rakes are then used in stirring and in equalizing the fluid preparatory to its being boiled, and the powdered pods put in to thicken it. When the mass is of proper thickness it is taken out and put into earthen molds, where it remains until it becomes quite hard. Then it is squeezed into the shape of balls the size of small apples. These balls are dried in the sun, and afterward stored away in a room, on shelves one above the other. When it is ready to pack in chests, a native climbs from tier to tier,



PERSPECTIVE VIEWS OF ZODIACAL BELT, ECLIPTIC, SUN, PLANETS, ETC.

Inside the belt are shown the constellations of the zodiac. On the outside various astronomical data are given.

forty feet above the cement floor, and drops ball after ball in quick succession, these being caught by a native below, until all the shelves are empty. Near the opium factory is a sawmill, where the wood is cut in proper lengths and made into boxes. In these boxes the opium is packed for shipment and home consumption. The odor of opium arising from the factory can be detected a long way off, and a visitor to the factory will soon realize a sense of drowsiness, as if he had taken a dose of laudanum.—Journal of the Society of Arts.

# UTILIZING WASTE WOOD.—II.*

## DESTRUCTIVE DISTILLATION; THE RECOVERY OF TURPENTINE AND OTHER PRODUCTS.

### BY F. P. VEITCH.

Concluded from Supplement No. 1723, page 22.

THE crude products from the distillation divide themselves naturally into four classes, as follows:

Non-condensable gases, 20 to 30 per cent; charcoal, 20 to 35 per cent; tar and oils, 5 to 20 per cent; aqueous distillate or crude pyroligneous acid, 30 to 50 per cent.

As has been said, it is the American practice to burn the gases and tar under the boilers, particularly in the hardwood districts, but it is highly probable that the tar is too valuable to be thus used and that it could be more profitably disposed of for other purposes.

While the chief and most valuable products of hardwood distillations are charcoal, acetic acid, methyl alcohol, tar, and acetone, a large number of other compounds are produced either primarily or by secondary reactions.

The gases produced during distillation constitute from 20 to 30 per cent of the wood and consist of about 53 per cent of carbon dioxide, 38 per cent of carbon monoxide, 6 per cent of methane, and the remaining 3 per cent of nitrogen, hydrogen, etc. These gases are of such low illuminating power that they are usually either burned under the boilers or retorts or are wasted.

The charcoal left in the retort when distillation is complete constitutes from 20 to 35 per cent of the original weight of the wood, the quantity depending on the kind of wood and the manner of heating the charge. The physical qualities and chemical composition of charcoal are governed chiefly by the temperature at which the wood is heated. When heated to about 280 deg. C. (536 deg. F.), wood begins to be friable and has a brownish black color. At 310 deg. C. (590 deg. F.) it is friable, takes fire readily, and is black in color. The coal becomes harder with further rise of temperature and is less readily ignited. As it is only 25 per cent as heavy as the wood from which it is made charcoal presents some advantages as a fuel, because of lower transportation charges. A good charcoal should be thoroughly burned without being brittle and should show the woody texture distinctly. The fracture should be conchoidal, lustrous, and quite black. It should have few cracks, the specific gravity should be high, and it should burn slowly without flame or smoke.

Charcoal is chiefly used in the manufacture of charcoal iron, for which purpose it is especially valuable, because of its low phosphorus and sulphur content. It is also used to some extent as a domestic fuel and as an absorbent and clarifier.

The crude wood tar produced when wood is distilled in retorts varies from 3 to 10 per cent of the wood. The portion separated from the crude pyroligneous acid by settling and that skimmed off of the top of the neutralized acid are united, and, after washing with water, may be sold in the crude state as "raw tar" or as "retort tar." It is used for preserving wood, for making roofing felts, as an antiseptic, and for the preparation of wagon grease and other low-grade lubricants. It is also a suitable raw material for the preparation of anilin colors, but finds no industrial application for this purpose, because of the low price of coal tar and the fact that the composition of the latter is better known.

In addition to the tar separated by settling, the crude pyroligneous acid contains considerable tar held in solution by the acids and alcohol present, which is recovered when the crude acid is distilled, and constitutes what is known as "boiled tar." It may be sold as such or burned under the retort, or it may be mixed with the raw tar and subjected to any desired treatment.

Wood tar, which varies in character with the kind of wood from which it is obtained, is a thick, dark-colored, viscous material still containing some acetic and other acids, and has a specific gravity of about 1.05 to 1.15. The crude or raw tar may be handled in several ways. It may be burned under the retorts, sold as crude tar, or subjected to fractional distillation for the isolation of its several constituents. To effect this the tar is placed in a suitable still and heated. When mixtures of volatile liquids are heated sufficiently high the distillate does not, as a rule, have the composition of the mixture in the still, but the various constituents pass over in a more or less pure form between certain definite temperatures. This method of separating the product in the still into its various components is known as fractional distillation, each portion as it distills or passes over being received separately from the other portions and called a fraction. Fig. 14 shows graphically what products are derived from the destructive distillation of wood, and the subsequent separation of these products by fractional distillation. In the distillation of tar, iron stills are employed and the first fraction or portion obtained consists of acetic acid and alcohol mixed with some of the light oils. The light oils distill below 150 deg. C. (302 deg. F.) and have a specific gravity of from 0.966 to 1.000; the heavy oils distill above 150 deg. C., have a specific gravity of from 1.014 to 1.021, and contain creosote, toluene, and paraffin bodies. The pitch, which constitutes from 50 to 65 per cent of the material, remains in the retort when the distillation is complete.

These several fractions, or portions, may be further purified, acetate of lime and alcohol being recovered from the first fraction, while the oily distillates are neutralized with milk of lime and redistilled. The light oils distilling below 150 deg. C. are used as solvents and for varnish making, while those distilling at 150 deg. to 250 deg. C. (482 deg. F.) are treated several times with alkali (boiling the alkaline solution in the air to oxidize impurities) and acid alternately and redistilled. The distillate obtained at from 200 deg. C. (392 deg. F.) to 250 deg. C. is commercial wood creosote, which has a yellow or brownish color and a smoky aromatic persistent odor different from that of carbolic acid. This is agitated with strong soda, the aqueous layer drawn off is rejected, the remaining oil is mixed with sulphuric acid and allowed to stand until creosote oil separates, when this is driven off with steam and redistilled finally from glass retorts. This product is a powerful antiseptic and is used as a disinfectant and preservative. The oils distilling above 250 deg. C. are used for burning.

Stockholm tar and pine tar or pitch, made by distilling pitch pine or other coniferous woods in heaps covered with earth (see Fig. 2), differ in composition from hard-wood and from pine-wood tar made in retorts and are regarded as more valuable. They are used for tarring ropes, calking ships, making soaps, for timber preservation, pitching barrels, and in preparing medicine.

When a crude aqueous distillate is first distilled in order to separate acids, alcohol, and acetone from the tar, some of the lighter oils which are present distill with the acid and alcohol, and finally remain in the alcohol still, or, if distillation is carried further, they pass over in the last stages and separate as an oily layer. This oil may be again distilled to recover any alcohol it contains, leaving the light wood oil, which is very inflammable and for which no profitable use other than burning has been devised.

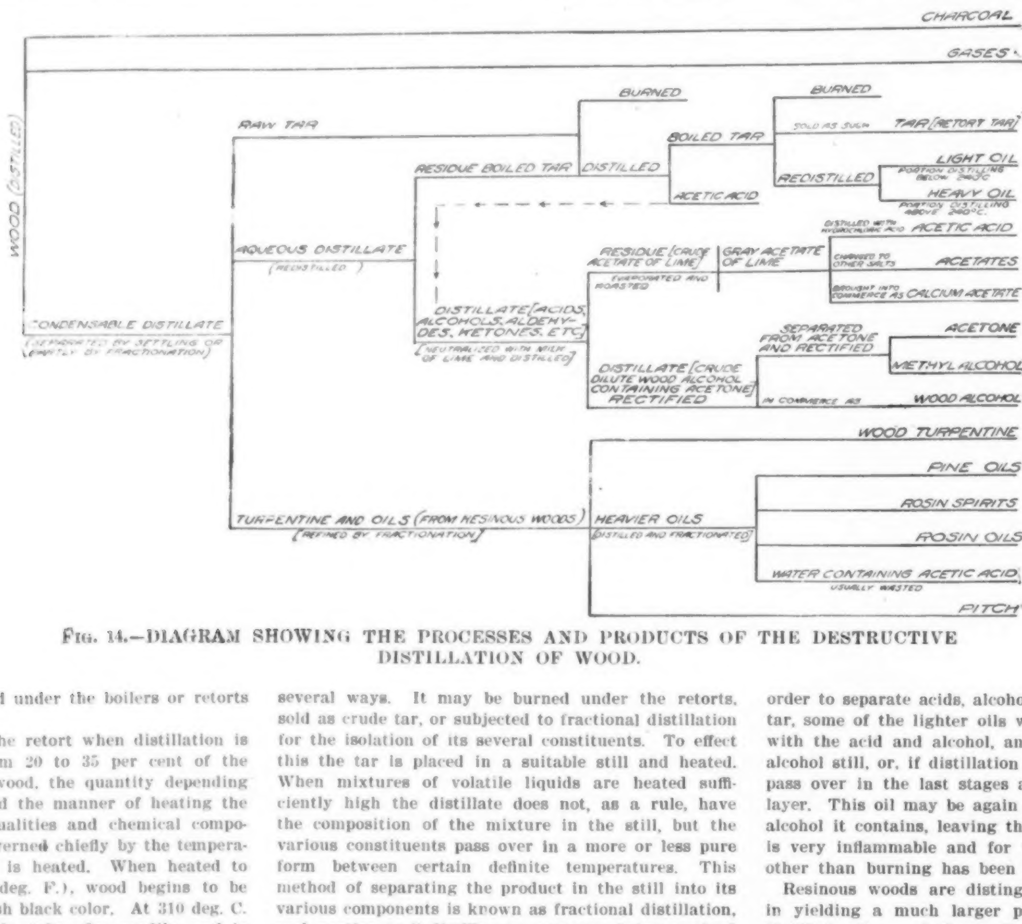



FIG. 14.—DIAGRAM SHOWING THE PROCESSES AND PRODUCTS OF THE DESTRUCTIVE DISTILLATION OF WOOD.

Resinous woods are distinguished from hardwoods in yielding a much larger percentage of oils when distilled. Some of these oils exist naturally in the wood, while others are derived from the breaking up of natural resins. When wood is gradually heated as in destructive distillation, and the temperature in the retort rises above 100 deg. C. (212 deg. F.), these oils mixed with water begin to pass over or distill, and continue with rising temperature until the distillation of the wood is complete. The oil passing from the retort at any moment may be different from that which passed previously and from that which follows it, so that in practice the distillate is a mixture of compounds having closely related chemical and physical properties, and this mixture increases in density and the boiling point rises with the temperature in the retort. By proper methods of treatment and fractional distillation oils of different physical and chemical properties may be obtained, and a number of such oils are on the market under various trade names. Some of these oils have not yet found a regular sale, however, owing to the fact that their composition is not definitely known.

Wood turpentine when properly made and refined has a specific gravity of from 0.860 to 0.880 at 20 deg

* Abstracted from a bulletin issued by the United States Department of Agriculture.

C. (68 deg. F.), though the first runnings from the still may have a lower and the last runnings a higher specific gravity; 95 per cent should distill between 150 deg. C. (302 deg. F.) and 185 deg. C. (365 deg. F.). This turpentine closely resembles spirits of turpentine from gum in most of its properties, and sells for from 2 to 10 cents less per gallon (depending on the care with which it has been refined) than gum spirits, for which it has been used as a substitute and adulterant. The processes of production and the technical value of this material are now being studied, but as the work is not completed no conclusion as to the relative value of wood turpentine as compared with gum spirits can be given at present.

Although considerable improvement has been made, wood turpentine still varies greatly in composition, much to its detriment commercially. That produced by steam distillation has, in well-refined turpentines containing but a small amount of heavy oils, a pleasant, fresh pine odor and but little color, while the heavier portions of the steam-distilled oils have a more penetrating and lasting odor, somewhat resembling that of camphor, and the more of these heavy oils the turpentine contains the stronger its odor and the more it differs from gum turpentine in all its properties. Turpentine produced by destructive distillation has a pungent, smoky odor, which the most careful refining will not entirely eliminate, and is usually more highly colored than the steam-distilled product. The oils that pass above 185 deg. C. differ from the last fraction of turpentine but little; indeed, there is no clear-cut distinction in these oils until rosin begins to break up into rosin spirits and rosin oils. For convenience, therefore, all the oils distilling above turpentine (185 deg. C.) and below the temperature at which rosin "breaks up" may be classified as pine oils, and they may be further divided into a number of portions or fractions. These oils are suitable for use in making varnishes, soaps, disinfectants, paints, inks, etc.

When, in the distillation of resinous woods, the temperature rises above 250 deg. C., not only is the wood attacked, but the resins in the wood also begin to break up, so that, with the acids, alcohols, ketones, oils, etc., formed from the wood, rosin spirits and rosin oils are formed from the rosin, and, if the latter are allowed to mix with the turpentine driven off at lower temperatures (which is always the case in straight destructive distillation), it is impossible to separate them perfectly from the turpentine in subsequent refining, because of the low boiling point of the rosin spirits. For this reason the odor of destructively distilled turpentine differs from gum spirits or steam-distilled wood turpentine and closely resembles that of rosin spirits.

Rosin spirit, with the exception of wood turpentine, is the best substitute known for gum turpentine, being much used in the manufacture of the cheaper grades of varnish and as an illuminant. Rosin oils are largely used in the preparation of axle grease and other low-grade lubricants; also in the manufacture of printing inks, leather dressing, and cement, and as an adulterant for other oils. Tar oils are obtained by distilling tar, and have many properties in common with rosin spirits and rosin oils. Those boiling at from 97 deg C. (207 deg. F.) to 240 deg. C. (464 deg. F.) closely resemble rosin spirits, while those boiling above 240 deg. C. contain phenol, creosote, rosin oils, etc., and, when freed from naphthalene and anthracene by cooling and from phenol and creosote by treating with alkali, are used as adulterants of lubricating oils.

Aqueous Distillate of Crude Pyroligneous Acid.—Comprising from 3 to 50 per cent of the weight of the wood, contains as its chief constituents, methyl alcohol (4 to 6 per cent), acetic acid (8 to 14 per cent), acetone (0.2 per cent), and tar held in solution by the acids and alcohol present, the balance being practically all water contained in the wood and resulting from its decomposition. This crude liquor is used to a limited extent in making "pyrolignite of iron," or "black iron liquor," an impure acetate of iron used in dyeing and calico printing. There are a number of different methods followed for separating the tar from this aqueous distillate and the several valuable constituents of the latter from each other. Raw tar is usually separated by settling all the liquors in large wooden vats, but even under the most favorable conditions the crude liquor still contains, dissolved in it, considerable quantities of tar, which interfere seriously with the purification of acetate of lime and alcohol prepared therefrom. In practice one of two general methods is used in handling the settled crude liquor. (1) It is neutralized directly with lime and the alcohol distilled; or (2) the crude pyroligneous acid without previous neutralization is distilled from the tar it contains. This is the better practice.

In both cases the substance produced by treating the acid solution with milk of lime is known as "gray acetate of lime." The liquor containing the acetate, whether brown or gray, is pumped to copper evaporating pans (Fig. 12, $G_1$-$G_2$), which are usually placed on the brickwork over the retort and the solution evaporated until the acetate begins to crystallize out, when it is transferred to a drying floor and stirred frequently until sufficiently dry. Gray acetate of lime contains from 80 to 85 per cent of actual acetate, the balance being tarry matters, calcium carbonate, and water. The gray acetate is used for the manufacture of acetic acid and other acetates and is largely employed in calico printing. It may be further purified by dissolving in water, filtering through boneblack, and evaporating the solution to 1.16 specific gravity,

FIG. 15.—LIMING STILL.

when the acetate crystallizes in small odorless needles which constitute the raw material from which acetone is made.

Commercial acetic acid is produced from gray acetate of lime or from brown acetate by distilling with concentrated hydrochloric acid or with sulphuric acid (Fig. 16). The latter is rarely used, as the calcium sulphate formed is difficult to remove from the stills and the impurities in the acetate reduce the sulphuric to sulphurous acid, which contaminates the acetic acid. Glacial acetic acid is prepared by heating fused sodium acetate with concentrated sulphuric acid in a porcelain-lined or earthenware still and then distilling, when a nearly anhydrous product is obtained, which crystallizes if cooled to 16.5 deg. C. (62 deg. F.)

The ordinary acetic acid of commerce contains about 30 per cent of anhydrous acid, has a specific gravity of about 1.040, and is slightly colored. It is used in the

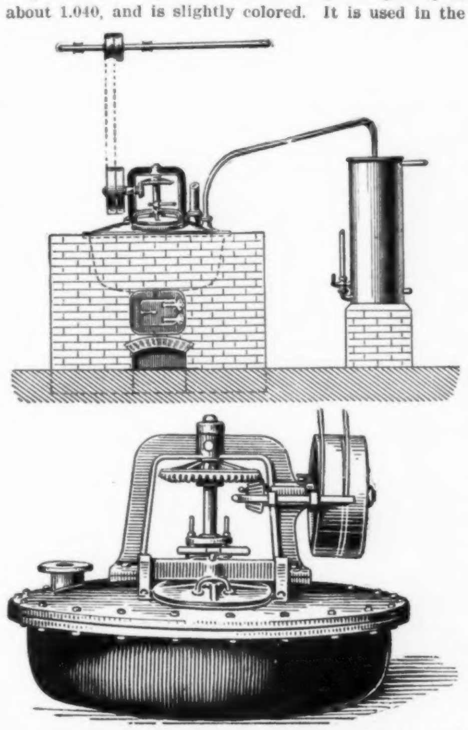


FIG. 16.—STILL FOR PREPARING ACETIC ACID FROM ACETATE OF LIME, WITH DETAIL OF ACETATE PAN.

preparation of acetates, the manufacture of white lead, and in pharmacy. Some pure acetic acid made from wood by distillation is used as vinegar, but such preparations have not the characteristics of fruit vinegar.

In addition to acetate of lime and soda the following are prepared for industrial purposes: Aluminium acetate, chromium acetate, copper acetate, lead acetate, sodium acetate, and crude methyl alcohol and acetone.

In the destructive distillation of wood the yields obtained in practice are much below those given under laboratory conditions. This may be due to destruction caused by local overheating in the retorts, loss of vapors around the doors of the retorts, incomplete carbonization, or imperfect condensation. Losses may also occur from incomplete or excessive overneutralization of acids with milk of lime, or to incomplete separation of alcohol and acids from the tar, or of alcohol from water. All of these points should receive the constant watchful attention of the superintendent, that such losses may be reduced to a minimum. Indeed, yields are largely controlled by the experience and technical knowledge of the superintendent. The almost total absence of chemical control in these industries doubtless accounts for many unprofitable plants, the source of whose failure can not be otherwise discovered.

The annual waste (in lumber sawmills), which is now sold for fuel in the United States, is, according to the Forest Service, equivalent to approximately 4,000,000 cords of wood, or within 800,000 cords of the amount now used in the destructive distillation (1,145,000 cords) and paper-making (3,647,000 cords) industries. If to this be added the waste, such as tops, lap, and dead and down timber left in the woods, this quantity is more than doubled, although no definite figures as to the total quantity can be given. The mill and forest wastes from resinous woods would yield a large portion of the turpentine and rosin now produced and several times as much soda pulp as is now made. The waste from the hardwood lumber industry would yield more charcoal, wood alcohol, and acetate of lime than is now being produced. The sawdust from the Southern pine mills alone will yield more oxalic acid than is now used in this country. The spruce and hemlock waste will yield at least one-half of the sulphite pulp now produced. The question is, can these industries be most profitably conducted in conjunction with the lumber industries, or independently? While, perhaps, a categorical answer applicable to all conditions can not be given at present to this question the above-mentioned facts strongly indicate that the proper industrial location of the chemical industries using wood as a raw material is in conjunction or close affiliation with the lumber industry. Such combination means cheap raw material and fuel for these industries and increased profits for the lumber industry, as well as the removal of waste which otherwise seriously interferes with the use of the land and is a constant menace from fire.

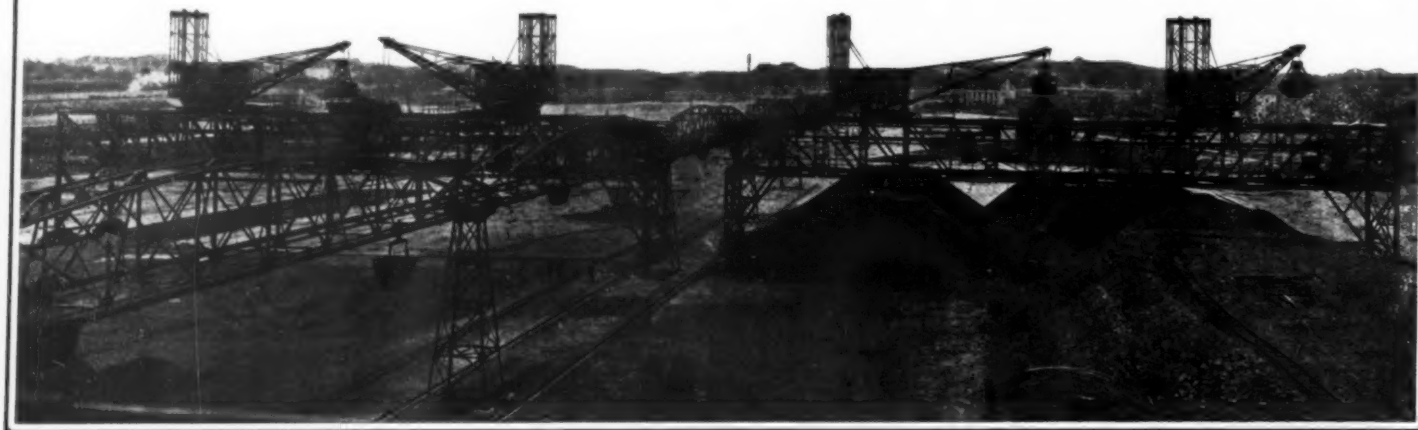
The gross values obtained per cord of wood are lowest when the wood is subjected to steam or destructive distillation, and it seems advisable, therefore, that attention be directed more to those methods of utilization which give larger gross values. Thus the recovery of turpentine and rosin by extracting with soda or volatile solvents, and using the residue for paper pulp or for making oxalic acid, are promising methods of utilizing pine wood that are receiving some attention from paper makers and investors, and their industrial value should be carefully determined. The demand for oxalic acid is, however, small as compared with available raw material, and could be readily supplied by a few well-equipped plants. In general, it may be said that all suitable wood should be used in producing the articles of greatest value, such as paper pulp, turpentine, and rosin, leaving oxalic acid to be obtained from part of the sawdust and destructively distilling only that wood which can not be more profitably utilized.

The production of the articles described has proved to be reasonably profitable, and will doubtless continue to be. Success, however, can only be expected under proper conditions. The plant must be close to the raw materials, as the latter are too bulky to profitably bear long transportation. There must be an ample water supply, as all chemical processes require large volumes of water for washing, dissolving, and condensing the products, and for making steam for operating the plant. The plant must be well constructed and equipped, that it may be operated with a minimum of power, that losses through incomplete reactions and condensation, imperfect separation, and leakage shall be at a minimum. Operation should be continuous and should be effected with as little hand labor as possible. For each plant certain working conditions will prove the most economic, and these must be discovered and provided. What these conditions are can only be learned through thoroughly competent technical and business control. It is essential that such plants be so managed that the working efficiency of any part can be learned at once and that there be some one who is competent to observe and interpret the results, as it is only in this way that errors are corrected and losses avoided. Those who are unacquainted with the technique of chemical industries are warned in particular against investing in these enterprises without satisfactory evidence as to the efficiency of the particular process and a knowledge that the plant will be under competent business and technical control.

**The largest** electrical steel plant in the world is being built in the French Alps at Ugine Savoy. It is situated on the river Arly, a glacial stream, and will develop 22,000 horse-power.

# LOADING AND CONVEYING PLANTS IN GERMAN GAS WORKS.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFC AMERICAN.



THE COAL-STACKING YARDS.

In connection with the manufacture of coal gas, in which the raw material is of low intrinsic value, the economic handling of the various products is of vital importance, since it influences to a remarkable degree the price at which the gas can be sold. In Germany this phase of the problem has undergone considerable development during late years, and the largest gas-manufacturing centers throughout the country are now equipped with a complete and highly successful economic and efficient means of handling the various materials from one point to another. In the selection of these transport facilities, due consideration has not only been taken of low first cost and working expenses for actual transit, but the loading and unloading of the bulk conveyed, this last-named factor being one of extreme importance. To secure the maximum of efficiency and economical working, it is obvious that both the conveying and loading systems should be co-related, so as to form two sections of one complete unit. That is to say, a perfect transportation system should not be nullified or handicapped by unsuitable loading and unloading facilities. Light surface railroads, while affording an excellent means of rapid transportation, are only partially successful, for the simple reasons that in extensive works, it becomes necessary to carry the conveying tracks at varying levels, approached by steel inclines, so that the problem has to be studied for two directions of travel —horizontal and vertical. At the same time, it is essential that it should be possible to reach any part of the works by mechanical means, and that the appliances adopted should offer the minimum of interference to general working and that the system should be of an elastic character, so as not to influence adversely an advantageous arrangement of the plant.

It has been found that these requirements are advantageously fulfilled by means of aerial ropeways, the application of which to gas works was first undertaken by Herr Adolf Bleichert, a Leipzig engineer, as far back as 1876. This line, which is still working, has a total length of 3,750 feet, and its installation resulted in the reduction of the conveying expenses from 24 cents to 9.5 cents per ton, although the quantity handled averaged only the small amount of 18 tons per hour. This remarkable economy, however, emphasized the possibilities of such a system for this field of industry, and its extensive development followed as a matter of course. During the past few years far-reaching improvements have been effected, which have resulted in a further heavier reduction in the working costs, with a corresponding increase in the capacity of the line, the existing average being 2.5 cents per ton, with an hourly capacity ranging from 200 to 300 tons. Probably the most striking and complete plants of this type which have been carried out by Adolf Bleichert & Co. of Leipzig are those at the Mariendorf works of the Imperial Continental Gas Association and of the Berlin municipal gas works at Tegel-Wittenau, both near Berlin. The first-named works have a daily output of 8,480,000 cubic feet of gas, and can be enlarged for an increased output when desired of 8,830,000,000 cubic feet per year. The municipal plant has an annual output of 10,600,000,000 cubic feet, which can be further increased to yield about 35,000,000 cubic feet daily. To gas engineers these two plants are of especial interest, since although the two plants are similar both in design and object, the details are widely divergent, while, moreover, it provides an informative illustration as to whether the stacking of coal for gas-manufacturing purposes should be preferably in the open or under cover, representing as they do examples of these two methods of storage respectively. Again, in the former plant the mechanical facilities are adopted only in connection with the coal-stacking traffic from the arrival station on the banks of the Teltow canal to the conveyor bands or yard stacks; but in the municipal plant, in addition to this, it is used throughout the whole course of production, including the transport of the coke to the yards, railway cars, or barges, as well as the handling of the solid residual products.

The Mariendorf plant when completed is intended to handle 200 tons of coal per hour, but at present only one-third of the installation is in working order. This first section comprises that extending from the unloading station on the Teltow canal, and conveys the coal from the barges to the storing yards or direct to the retort houses, and between the stacking depots and the retorts. Upon the canal banks are traveling ship-unloading cranes running on rails. By means of these the coal is withdrawn from the barges by two independent grabs, which discharge their contents into large hoppers within the framework of the crane. In front of each hopper extends a short track of the mechanically-driven suspension railway fitted to the framework of the crane, and consequently traveling with it and connected with the main fixed line by tongued rails.

After leaving the unloading point the railway runs to a combined turning and driving station, there being three sections extending from the unloading station to this junction. From the crane station the line ascends a gradient to the turning station, whence it runs at an altitude of 33 feet horizontally between two coal-stacking depots to the retort houses, also turning into branch lines, of which each serves dumping stations and three retort houses. Traveling bridges furnished with suspension rails are joined on to both sides of the above tracks, the rails being connected by automatic lever switches to the fixed suspension rails of the tracks. Each depot can be stacked with coal throughout its entire length and breadth. For taking up coal from the depots each traveling bridge has two rotary cranes, which lift the coal by automatic grabs and deposit it in hoppers from which the railway cars are loaded.

The cranes at the canal station have an hourly capacity of 100 tons, thus requiring each of the grabs to make from 25 to 30 hoistings per hour. The grabs, of 106 cubic feet capacity, are of special design, built on the two-rope system, so that they can be shut or opened at any desired height. The cranes themselves are of the gantry type, with two rotary jibs and tracks for two trolleys. The crane engineer has four distinct motions under his control—the travel of the whole bridge, running of the trolleys, hoisting and lowering of the grab, and short slewing of the jib. This arrangement enables the grabs to work upon any part of the ship or barge moored alongside without requiring the latter to move in any way. The power needed for each grab is about 100 horse-power, the trolley-driving motors require about 5 horse-power each, the slewing motor about 8 horse-power, and the crane-driving motor about 12 horse-power, making a total of about 230 horse-power for the whole plant.

The crane is of substantial construction, and so designed as to possess an ample factor of safety in heavy winds. The crane bridge travels on 32 wheels. The traveling speed is about 33 feet per minute. The hoppers within the crane frame, into which the unloaded material is dumped from the unloading grabs, have patent locking flaps, and so arranged that the openings cannot very easily become blocked by large pieces, or if so, blockages can easily be removed from the outside. After being loaded the cars are pushed over by hand to the main line, passing in so doing over the automatic weighing machine, where the weight of the car is not only automatically recorded, but the number of cars which pass over it, as well as totaling the weights ascertained. Suitable precautionary methods are adopted to prevent tampering or dishonest practices by the workmen, such as counting or weighing a second time. Leaving the weighing machine, the car is pushed over to the continuous traveling traction rope of the railway, and hauled up a 6.1 per cent grade to the driving and turning station. Thence the track is carried to the stacking yards under a number of parabolic bridge supports having spans of 133 feet (one of 114 feet) each of a weight of approximately 156.5 tons.

The present capacity of the plant is 100 tons per hour, but all constructional calculations have been carried out on the basis of the maximum of 200 tons, so that when the time arrives for working the line up to its designed output, no alterations to the track will be necessary, but it will only be essential to employ a greater number of cars. These have each a capacity of 2,640 pounds, and upon the present output 85 cars are dispatched hourly, or one every 42.4 seconds. The cars are spaced about 113 feet apart, and have a traveling speed of 48 feet per second. Working at full capacity, the distance between cars, as also the intervals at which the cars are dispatched, will be reduced by 50 per cent. The cars are of sheet steel fitted with wheels operating on the Bleichert "Automat" jaw-grip system, which acts by the weight of the car, and furnished with locking arrangements for automatically emptying on the track. The traction rope is of 0.7 inch diameter, made of patent crucible cast steel and having a total breaking strain of 43,900 pounds. At present some 16 horse-power is necessary for driving the ropeway, the first section requiring 7 horse-power and the second 9 horse-power, furnished by an electric motor at the driving station.

By this arrangement the number of men required to supervise or participate in unloading and transportation operations is reduced to the minimum, being confined to the unloading crane at the canal station, the driving station, and retort houses. All curves and bridges of the stacking yard are traversed without any attention whatever. When the coal is being taken from the barges and dumped at the depot, the retort house section is disconnected, so that the men at that point are released, and can supervise dumping; while similarly, when the retorts are being charged with coal taken from the depots, the canal station section is thrown out of gear.

For loading the cars in the depots there are two rotary cranes, each having a capacity of 50 tons per hour, built on each of the unloading bridges. The weight of the grab is for the most part balanced by a 13-ton counterweight requisite for the stability of the crane and also to economize the working power, the effect of this arrangement being that hoisting can

be effected at a speed of 1.6 feet per second with a motor of 35 horse-power, whereas otherwise 100 horse-power motors would have been necessary. Slewing speed of the jib is so calculated as to enable the grab to move in a circle at a speed of 4.9 feet per second. Each crane bridge has a total span of 190 feet, and runs on two lines fixed in the stacking yard parallel to the middle fixed suspension railway bridge. The bridges are mounted on sixteen wheels, eight for each line. The bridge is a double lattice girder carried on triangular supports at either extremity, so as to form an arch with a clearance from the underside of 23 feet. The maximum weight of each bridge, including cranes and contents of hopper, etc., is about 250 tons, giving a wheel pressure of only 15 tons, and the crane track consists of lines weighing 96 pounds per yard laid on longitudinal rails, which in turn are carried on brick foundations to render settling impossible and to reduce upkeep to practically *nil*. The bridge is driven from both ends, so that any swaying in traveling is entirely avoided, the speed being purposely kept somewhat low, being 50 feet per minute, and actuated by two 25-horse-power motors.

The plant has proved highly successful and economical in working. For the complete supervision of the whole conveying plant, including cranes and railway, only ten men are necessary. The cost of transporting coal from the depots to the retort houses only averages 3.5 cents per ton, and from the canal to the depots or direct to the retort houses, 4 cents per ton inclusive.

At the Berlin municipal gas works at Tegel-Wittenau the transporting and handling plant is more extensive, since in this case a multitude of operations are performed by a uniform system. Similarly, this plant is calculated for a greater capacity than at present required, and indeed when completed will enable 700,000 tons of coal per year to be unloaded from vessels for temporary deposit at the depots or conveyance direct to the retort houses. Also the quantity of coke to be conveyed from the retort houses to the stacking yards or other desired point annually aggregates 300,000 tons, giving a total single transport of some 1,000,000 tons per year. Inasmuch, however, as much of this traffic has to be handled twice, the amount of traffic running over the suspension railway lines will total 2,000,000 tons per annum, the highest figure which has as yet been reached for traffic on a mechanically-driven suspension railway. In the planning of this scheme, the highest possible economy in labor was one of the most vital considerations, combined with adequate provision against disorganization of the system from breakdown. In the whole of this project every line and every rail has a reserve, so that should interruptions either slight or serious occur upon any section, traffic may be continued over the duplicate. Moreover, in these works considerable differences of level had to be taken into consideration, and such variations are not simply overcome by lifts or slanting banks, but arrangements are provided to enable the suspension cars to take the course over suitable graded inclines and intermediate lifts, so that throughout a duplicate service is available. This duplication system has been carried out to such an extent at Tegel that a breakdown in the traffic is out of the question, unless a large part of the plant is destroyed.

In regard to the loading station at the wharves for the transshipment of the coal from the vessels to the suspension railway cars, the facilities are similarly arranged to those at Mariendorf, only the number of traveling double cranes is increased. In this case, however, the cranes run on a specially low bogie over an elevated railway at the side of the dock, which in turn takes up two suspension railways. This arrangement avoids the heavy grade from the unloading station to the driving station, such as is unavoidable at Mariendorf.

At these municipal gas works the coal is stored under cover, the coal shed measuring 1,913 feet in length by 173 feet wide. The general objection raised against such storage is the increased cost of the plant arising from the erection of such accommodation, combined with the facilities for withdrawing the material from beneath the shed. In this instance, however, some very striking novelties in construction have been adopted, whereby a considerable economy in first cost was secured. Extending longitudinally and centrally through the shed is a substantial pier continued from the foundation to the roof, which acts as a support. On either side the space is spanned by a traveling bridge having a clear span of 85.3 feet, along the suspended rails of which the loaded cars travel and dump their contents where desired. In this manner a perfectly even distribution of the coal throughout the shed is rendered possible with facility. The suspension railway cars pass a tipping switch formed by the traveling bridge, and which with the assistance of self-switching electric power makes a slight forward movement after the car has been tipped, so that the contents are distributed in layers.

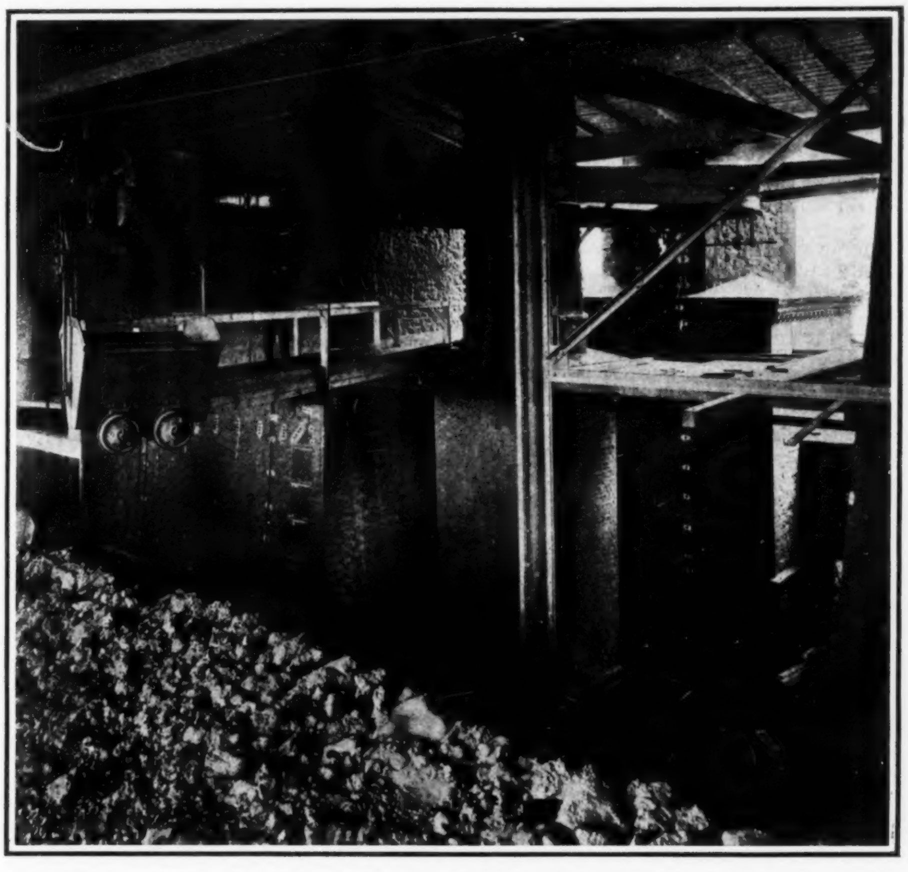
The coal is withdrawn from this shed beneath the floor, which is carried upon arches, there being the usual slanting shoots for charging the cars of the suspension railway extending through the building beneath the floor. These shoots, however, are not free, but are built into the middle pillars, which serve at the same time as supports for the lower slanting floor. This insures a particularly advantageous and economical arrangement of the shoots. There are fifty passages in the shed, each provided with twenty openings for emptying, so that in accordance with usual practice 1,000 special shoots or hopper lids would have been necessary, the fitting of which would have alone cost from $62,000 to $75,000. At the same time, it must be remembered that the whole of these thousand shoots would not be in service at one and the same time, so that to all intents and purposes a large amount of plant would be idle. At the Tegel works this disadvantage has been ingeniously surmounted. Instead of the outlets being equipped with fixed shoots, they are all closed with movable bars which can be withdrawn quickly and easily one by one from the side. As a result, only some twenty hopper shoots are required, and these are mounted on traveling frames. These are fixed at any desired outlet, made fast by suitable devices, and when the outlet-closing bars are removed, the coal runs out in the usual manner, falling into the suspension railway cars. By the adoption of this system an outlay of $50,000 was saved in the cost of the plant, and by its means it is possible to draw off up to 120 tons of coal per hour per shoot.

Some idea of the extent of the suspension railway in this shed may be gathered from the fact that the length of track in the shed is 1.25 miles, and in the cross section 1.5 miles operated by hand, making in all 2.75 miles of track.

The coal, whether brought from the storage shed or direct from the vessel to the retort house, is first carried over the coal-breaking plant; and in order to secure a suitable distribution of the material, what is described as a distribution frame is inserted at this point, from which the empty cars, after discharging their loads, can be pushed over manually on to the several ropeway lines. In the retort houses the whole of the conveying operations is carried out by this railway. A double-line suspension track is placed near the roof of the retort house, but sufficiently clear thereof to enable the coal bunkers to be reached easily. The cars picking up their loads from the coal breaker are driven across this track, and by means of automatic tippers, with the assistance of suitable striking levers, discharge their contents into the bunkers, the actual loading appliances consisting of funnels disposed at various suitable levels of sufficient capacity to take enough coal for charging one retort.

The coke is removed by similar facilities. This line is carried through the retort house two floors below the coal-carrying line. The coke withdrawn from the retort falls into Merz troughs in the floor, where it is quenched and then transported to small bunkers, one of which is disposed between each two furnaces. In communication with these bunkers is a slanting elevator, which lifts the coke and throws it into intermediate bunkers from which the cars are fed. The laden cars following in quick succession bear the coke away to the coke dumps. A third track extends through the retort house for the transportation of the ashes and slag, this owing to its small capacity being manually operated.

The laden coke cars run automatically to the dump, which has a length of 667 feet by 150 feet wide. On either side of this depot runs an elevated railway, carrying forward and return suspension railway tracks, which thus practically inclose the whole of the coke depot. The laden cars run on to a traveling bridge spanning the whole space, similar to that at the Mariendorf coal depot, and tip their contents, the arrangement of this plant being very similar to the Mariendorf coal-stacking installation. There is a second elevated bridge of some 160 feet span, carrying a grab for reloading cars with coke for the treatment station, and which has a radius of action over the whole depot. The coke withdrawn in this grab is emptied into a hopper, from which the cars are filled. The coke-carrying sections of the railway extend to a land station for filling railroad cars; another point for charging high road vehicles, and also to the wharf for loading barges. Similarly, a section is devoted to the handling of the chemical by-products. Altogether there are some 11.25 miles of suspension railway in operation, which when completed will total approximately 25 miles. The Mariendorf and Tegel installations possess at present the largest transport tracks in the world yet erected for gas works; and the complete success that has attended their installation, combined with facility and equal efficiency and economy of operation to small as well as large gas-producing manufacturing plants, has resulted in similar equipments being erected at various smaller European gas works.



ELECTRIC SUSPENSION RAILWAY WITH HOISTING AND LOWERING WINCH AND AUTOMATIC STEERING GEAR AT WORK IN RETORT HOUSE.

LOADING AND CONVEYING PLANTS IN GERMAN GAS WORKS.

**There are at present** two new electric locomotives in use on the Simplon tunnel line, and they have been running in the tunnel for some months past. As yet there has been no description published of these locomotives, as the manufacturing company expect to give a complete description before long. Having examined the new locomotives, however, we are able to give some of the leading points about them. They are newly constructed by the Brown-Boveri firm of Switzerland, and are claimed to be an advance upon any thing in the way of electric locomotives which has

yet been brought out in Europe. One point in which they differ especially from the preceding type which is still in use on the Simplon road is the method of coupling together the driving wheels. In the other locomotive which was built by the same firm, there were two main driving wheels in the middle part and two smaller wheels on either side. The two main wheels were coupled together by a connecting bar, and a similar bar coupled the inner of the small wheels on each side to the corresponding driving wheel, making thus three coupling bars in all. On each side of the center there is an electric motor which drives each main wheel by a crank coupling to the main bar. The new locomotives have also two motors and a central driving bar for the middle pair of wheels, but this bar is connected on each side not only to the first small wheel, but also to the second by another bar, so that all the six wheels of each side are driving wheels instead of four. The engineers of the road are very well satisfied with the new locomotive and state that it is superior to the former type. On the overhead wire 3,000 volts is used, and the bow trolley brings the current to the transformers of the locomotive which vary the voltage for the motors so as to give the different speeds. Next the transformers in the sloping end of the locomotive is mounted a horizontal controller driven for changing the transformer connections. It is operated by compressed air, and on the motorman's bench are the levers for operating the compressed air supply and thus changing the motor speed. In general the trains are run in the tunnel at a maximum speed of 40 miles an hour. On the tests, as many as 24 cars can be taken by the locomotive, representing a load of 500 tons. There are four electric locomotives now in use, two of the old and two of the new type. In the latter the motors give 650 horse-power each. The motors themselves are of an entirely new electrical design and are arranged so that the number of poles can be changed. All the switching and controlling operations are carried out by compressed air, as well as the raising and lowering of the trolley.

# PAPER-MAKING MATERIALS.*

## SUGGESTIONS FOR THE MANUFACTURER.

### BY F. P. VEITCH.

#### INTRODUCTION.

THIS monograph has been prepared to meet a demand for general information as to the suitability of various products, most of which are not now employed, for paper stock, and also to suggest ways of maintaining sufficient quantities of paper-making materials in the future. No directions for paper making are given. It has been established that numerous materials, while technically suitable for paper making, can not be so employed for economic reasons, but by a rational and conservative use of the materials now employed, the problem of a sufficient supply of paper stock can be much simplified. For this reason, suggestions based largely on the work of the Bureau of Chemistry are here made which, if followed, it is believed would result in greater economy in the use of raw materials as well as in lower cost and better service to the consumer without material reduction in total values. It should be distinctly understood that the figures on the waste materials are only estimates. It has been the aim to make these very conservative, as it is recognized that it is impossible to give even approximately accurate figures as to the quantities of such materials, the amounts that could actually be secured for paper making, or their cost. The aim is to direct attention to the large quantities of suitable material now wasted, leaving to the future the working out of the details of their profitable utilization.

The woods from which the greater part of the paper produced in this country is made are becoming scarcer and are obtained at greater cost each year. This fact has occasioned some concern to the paper industry in the past few years, so that manufacturers and investigators have turned their attention toward other agricultural products, many of which have been shown to be perfectly suited for paper making as far as the quality of the product is concerned. All kinds of wild and cultivated plants which are available in large quantities as well as all kinds of fibrous wastes have been used either experimentally or on a manufacturing scale for paper making. These facts are well known to paper makers, who have themselves experimented on a mill scale with many materials—woods, plants, and fibrous wastes—and have placed their treatment on a practical basis. Nevertheless many inquiries are constantly received from paper manufacturers and others as to the possibilities of making paper from some new material.

Practically all fibrous vegetable materials will make paper, the quantity being governed by the percentage of fiber sufficiently resistant to stand the action of the chemicals necessary to reduce to a working condition the most resistant fibers, while the quality of the paper which these materials will make is determined by the length, strength, and felting qualities of the fibers and the chemical nature of the cellulose which they contain; the longer and stronger the fibers and the purer the cellulose (the more closely it corresponds to normal cellulose), the better the paper, the longer it will last, the more wear it will stand, and the less it will discolor with time or use.

#### CLASSIFICATION OF MATERIALS.

The materials which may be used in paper making can be roughly divided into four groups:

(1) Seed hairs, of which cotton is the only representative.

(2) Bast fibers, such as flax, jute, hemp, ramie, China grass, sun hemp, common nettle, paper mulberry, and the fibers obtained from the fibrovascular bundles of plants such as manila and New Zealand flax.

(3) The whole stems and the leaves of straws and grasses, such as esparto (leaves only), corn, sugar cane, bamboo, other wild and cultivated grasses, cotton stalks, and materials of like nature.

(4) The various kinds of wood, those most used being spruce, hemlock, poplar, and cottonwood.

Most of the materials of the first three classes are used in paper making in the form of wastes from other industries; those of the first two classes as scutching, mill, and rag wastes of the textile industries; while those of the third class are used in the form of wastes from the agricultural industries. Esparto, bamboo, and paper mulberry are not wasted from other industries, but are gathered primarily for paper making. The use of materials in the form of waste is not due to particular difficulties in separation or handling nor to the unsuitability of the original material, but solely to the fact that these materials in their original form command a higher price for other purposes than for paper making. Indeed all of these materials will make paper of greater strength, durability, and value before going through other manufacturing processes, or when used in the form of worn and soiled rags. For example, new cotton fiber, as baled cotton, or that known as "linters," which is removed from the ginned cotton seed as a preliminary step in the cotton-oil industry, is perfectly suited for the manufacture of high-grade paper, but the demand at the price that must be asked does not justify the use of this material for paper making. Similar conditions exist as to the materials of the second class, which command from 3 to 20 cents per pound for the manufacture of cloth, bagging, ropes, and cordage.

The materials of the first two classes, because of the length, strength, and felting qualities of their fiber and the resistance to chemicals and to decay of the cellulose they contain, can be made into papers of the highest quality, and each material gives certain characteristics and individuality to the paper made from it. It is customary to consider the first two classes together.

The materials of the third class belong chiefly to the class of compound celluloses known as pecto- and ligno-celluloses, and are distinguished from the paper-making point of view not only by the presence of celluloses of different chemical composition and lower felting qualities, but also by a larger content of non-fibrous cellulose which, although it has some desirable qualities even when present in large quantities, as in bagasse or cornstalks, produces parchment-like effects in the papers made from them. A further technical objection to these materials is that the chemical treatment required to reduce the fiber properly is too severe for the non-fibrous cellulose, which is overcooked and partly dissolved, resulting in low yields of weak paper. Esparto, of which only the leaves are used, is an exception to these general statements, and yields a larger percentage of a strong, uniform fiber than the other members of this group. This class of materials, except esparto and bamboo, have, as a rule, short fibers and yield a small quantity of low-quality paper in comparison with the other groups, though some of them are not markedly different from woods in the latter respect.

For the past twenty years wood, chiefly spruce and poplar, has furnished the greater part of the paper made in this country. In 1907, 3,962,660 cords were used, yielding on an average 1,200 pounds of pulp per cord of wood, or a total of about 2,547,879 tons of pulp, which would make approximately 80 per cent of the paper and board annually produced in this country. The fibers of the soft coniferous woods are longer than those of the hard deciduous woods, the former being from 1 to 4 millimeters in length, while the latter are from 0.5 to 2.5 millimeters long. Spruce is more commonly used for making ground wood and pulp by the sulphite process, while poplar is almost exclusively reduced by the soda process. However, these woods may be treated by either process, depending on the cost of material, the location of the mill, etc.

Because of the exhaustion of the supplies of spruce and poplar within a reasonable distance of the mills, large quantities of other kinds of wood have been used for many years, not only for making board, bogus manila, and wrapping papers, but also for white papers, such as are used for news, book, and low-grade writing papers. Thus in 1907, 576,154 cords of hemlock, 78,583 cords of various kinds of pine, 43,884 cords of balsam, 66,084 cords of cottonwood, and 125,162 cords of other kinds of wood were used for making paper, the larger part being chemically treated. Among the pines, white, gray, loblolly, and longleaf yellow pines are being used, while among the miscellaneous woods employed are red and white fir, larch, aspen, gum, cypress, beech, birch, maple, basswood, buckeye, and chestnut; other woods which are available in large quantities are being constantly experimented with at various mills. Indeed, practically all woods may be used for paper making, such use being governed chiefly by the character of the wood supply near the mill.

The reasons that have made wood the cheapest and preferred paper-making material are clearly evident. They are low cost of raw material; ease of transportation and handling, particularly by machinery; freedom from dirt; uniform supply, and low digester requirements, as much more wood can be placed in a given digester than any other material. Further than this, mills could be built and operated close to the material. But the spruce and poplar forests contiguous to many of these mills are gone and they can no longer obtain their wood at the old price nor at a price that will enable them to compete with mills more recently built, which are still close to a wood supply. Neither can such mills, built to use wood advantageously, use other materials in competition with mills especially built and equipped for using those materials. The demand developed in the past few years and constantly growing is not primarily so much for new materials as it is a demand for wood at a price that will enable the poorly situated mills to compete with those more economically located with respect to their supply. This demand can only be met either by a large use of other woods or by planting and growing spruce and poplar.

#### YIELDS OF PULP ON A MANUFACTURING SCALE.

The percentage yield of pulp and paper varies with different materials, and that from a given material varies with the severity of treatment to which it is subjected and the kind of paper made—the better the quality of paper the lower the yield. The yields usually obtained from the more commonly used materials are as follows:

| | Per cent of paper obtained. |
|---|---|
| Rags | 70 to 80 |
| Esparto | 40 to 45 |
| Straw | 40 to 50 |
| Wood, sulphite | 40 to 50 |
| Wood, soda | 40 to 50 |
| Waste fibers, paper, bagging, scutching waste | 75 to 90 |
| Bamboo | 40 |
| Jute | 50 |

* A circular issued by the Bureau of Chemistry of the Department of Agriculture.

POSSIBILITIES OF SOME MATERIALS NOT COMMONLY USED.

Besides a proper and conservative utilization of wood, the demand for paper stock may be filled by a more extensive use of other well-known and thoroughly developed materials. The use of these is controlled by the total cost of manufacturing from the cheapest substance an acceptable paper. As has been said, wood is the cheapest paper-making material now obtainable in large quantities. Therefore competing materials must produce paper at as low a cost at the point of consumption as wood does. The local use of other materials is feasible in sections which are distant from mills making paper from wood, as in the Mississippi Valley and in the coast regions of the Southern States, where the total cost of the papers now used is increased by the cost of transportation from distant points. In the never-ceasing search for materials many previously exploited substances are rediscovered from time to time and more or less transient interest taken in them. These materials belong, almost without exception, to the third class mentioned above and rarely possess sufficient merit to compete with those which have been employed regularly for many years, and which experience has demonstrated are the cheapest and best suited to the purpose.

Basis of Valuing New Material.

Paper making on an industrial scale is governed by the supply of raw material, the quality of paper it will make, and the total cost of manufacturing it into paper. In valuing a material, therefore, it is as necessary to know how much there is of it and how steadily this supply will be maintained as it is to determine the quality and quantity of fiber it yields, the cost of gathering, transporting, and converting into paper, and whether it can compete economically with other materials used in making the same grade of paper.

In forming an opinion as to whether there is a sufficient supply of the material to justify its use, the fact must be borne in mind, particularly if a mill is to be built, that it is not a question of a temporary supply, but of a continued supply, that there should be enough available to meet all requirements for a number of years. Estimates on these points can only be formed after careful consideration and examination of the source of the material, taking into consideration whether it is naturally grown or cultivated, whether it is an industrial or agricultural waste, and whether it can be obtained in a satisfactory condition as to cleanliness. The value of the material for other purposes must also be considered; if this is greater than the paper-making value, it is useless to consider the subject further.

When it has been determined that the supply of the material is sufficient, samples should be examined in the laboratory. The composition of the material and its adaptability to paper making, as well as a fairly accurate idea of the character of paper it will make and the cost of treatment, can all be determined by a laboratory examination, saving a great deal of experimenting in the mill, which is both costly and time consuming. Such an examination can be made in any well-equipped paper laboratory and may be then followed by a mill test on a small scale. The results secured in these ways are rarely duplicated on a commercial scale, so that methods of treatment can only be perfected by experiments in the mill, and in all cases the results should be so confirmed before large sums are invested.

The laboratory examination indicates at once to which of the previously mentioned classes the materials belong and shows the quality and general character of paper which it will make. It also indicates the time and pressure required for the necessary cooking of the material as well as the quantity of chemicals needed in cooking and bleaching. From these data the cost of treating may be approximated. Moreover, the quantity of paper made by a given weight of the material is shown, and from the quality and quantity produced the market value of the paper can be estimated. Materials are valued by comparison with rags, which are the standard for the highest grades of paper, or with wood which makes a good grade of white paper, for the treatment of both of which the mills have been especially designed and located. It is therefore quite evident that materials which are expected to compete with these standard materials must yield a paper fully equal to them in strength, durability, cleanliness, texture, and appearance, and the finished paper must cost no more per pound.

The last factor in valuing a material is the total cost of making paper from it, and this is obtained by adding to the cost of making the expense of gathering and transporting the material to the mill. The yield per given area, cost of harvesting, difficulty of handling, relative bulk of the material, and cost of transportation must all be considered. Whether the waste is one which is always harvested, as are straw and sugar cane, or is usually left ungathered, as are cotton stalks, is a point which also affects the cost.

The relative expense of making paper from different materials can not be discussed in detail. It may be said, however, that the cost of chemicals per ton of paper is greater, as a rule, for wood than for other materials, and the time of cooking is longer. On the other hand, wood is cleaner, more can be placed in the digester, and the pulp requires less beating than longer and stronger fibers. What difference there is in the cost of mill treatment of the various materials, provided they pass through all the chemical processes and are used in the same grade of papers, is probably in favor of wood. Therefore only those materials which will yield an equal quantity of as good paper and which can be delivered at the mills at no greater cost can compete successfully with it. In other words, it is largely the cost of the raw substance rather than the mill treatment that determines the availability of paper-making materials. The relative cost per ton of paper on the basis of the assumed cost of the raw materials is shown by the following table:

Cost of Raw Material Required to Make 1 Ton of Paper at the Stated Price for the Raw Materials.

| Material. | Cost of Material at Mill Per Ton. | Yield of Paper, Per Cent. | Cost of Material per Ton of Paper |
|---|---|---|---|
| Wood | [1] $6 | 40 | $10.00 |
| | [1] 8 | 40 | 13.25 |
| Cotton stalks, straw, bagasse, cornstalks | 2 | 35 | 5.75 |
| | 5 | 35 | 14.33 |
| Flax straw | [2] 3 | 80 | 19.00 |
| | [2] 5 | 80 | 32.50 |
| Old bagging | 16 | 80 | 20.00 |
| Scutching waste | 20 | 80 | 25.00 |
| | 40 | 80 | 50.00 |
| Linters | 20 | 80 | 25.00 |
| | 60 | 80 | 75.30 |
| Waste paper | 10 | 90 | 11.00 |
| | 40 | 90 | 44.50 |
| Rags | 20 | 80 | 25.00 |
| | 120 | 80 | 150.00 |
| Manila and hemp rope | 40 | 80 | 50.00 |
| Esparto | 20 | 45 | 44.50 |
| Hemp fiber | 40 | 80 | 50.00 |
| Cotton | 100 | 90 | 111.00 |

[1] Per cord. [2] Based on 400 pounds of fiber per ton.

Greater cost of production alone, due chiefly to greater cost of raw material, or coupled with lower quality of product, renders impracticable the use of many wild and cultivated plants. Thus an initial cost for straw of $5 per ton at the mill prevents its competing with wood at $8 per cord for making white paper. The same statement holds in a general way for marsh grasses, sugar-cane bagasse, cornstalks, cotton stalks, etc., from all of which acceptable papers can be made, but at a greater cost than from wood under present conditions.

One other factor should be considered, namely, the cost of paper at the point of consumption. There are undoubtedly localities where, because of their distance from the commonly-used raw materials, the unusual materials can be and are used to a limited extent to supply local demand. This is particularly true of the lowest grade of paper, such as box boards and pasteboard, for which straws of all kinds are suitable. The conditions under which utilization, as far as white papers are concerned, is possible must be very carefully considered for each particular case, but are of course chiefly controlled by the difference between cost of production plus transportation on the one hand and cost of production at the point of consumption on the other.

Finally, from a consideration of the foregoing facts it is evident that the whole subject of new materials is a question of their relative cost rather than a technical one as to their paper-making possibilities. As has been said, broadly speaking, any fibrous vegetable matter will make paper, but its use for this purpose is controlled by the value and cost of the product. It is therefore true that with a rise in the price of the materials generally employed, others will be more largely used and most profitably when obtainable close to the paper mills. For these reasons consideration should be given to some of the proposed materials.

Utilization of Mill and Forest Waste.

With the present methods of removing bark, rotten wood, and knots, the utilization of mill wastes for making any but low-grade colored papers or boards seems impracticable. If all suitable material is used, as it should be, for making laths and other small articles, the waste from a mill would be too small both in size and quantity to be profitably handled as a paper material. There are, however, large quantities of wood left in the forest which is of sufficient size to be used advantageously by the methods now in vogue. While it is impossible to give an accurate estimate of the material thus available, it is probably safe to say that fully 25 per cent of the tree which has been cut for lumber is still available for paper making and, when properly graded, offers no particular difficulty in treatment at the mill. On this basis fully 12,000,000 cords are available annually as waste from the lumber industry, and furthermore it is obtainable in large quantities over small areas, and, being a waste of the lumber industry, can doubtless be obtained at a lower cost than wood direct from the stump.

Utilization of Straws and Wild Grasses.

Straws and other grasses contain compound celluloses which exist both in the form of fiber and of nonfibrous cellular material, and yield from 30 to 50 per cent of white paper. These substances are likely to contain much dirt, collected from the ground, which is difficult to remove; if any remains, it increases the cost of treatment and mars the quality of the paper. Cereal straws were generally employed for the cheaper papers before wood was used, and even now are used extensively for making papers and board. As has been said, the cost of making a good quality of paper from these materials, except possibly under exceptional conditions, is greater than from wood, but they are suitable for making cheap wrapping papers and boards when the proximity of the mills to the raw material and increased yield compensate for somewhat greater original cost of raw material or greater cost of treatment.

Special mention should perhaps be made of rice straw, with which some experimental work has been done recently in this country. Examination of the fiber and of pulp made from the straw indicates that the paper made from it is similar in all respects to paper made from the more commonly used cereal straws, and any advantage which this material may possess over the latter is due to local conditions under which it is produced. In the tide-water regions of the Southern States, far from the chief points of paper production, paper may possibly be made from the large quantity of rice straw now wasted for less than it can be made in the present paper-making centers and transported to southern markets.

With the straws may properly be included the "herds" of hemp, and the broken stems produced in "breaking out" this fiber, as well as bagasse, and cornstalks. These latter materials contain more cellulose in the non-fibrous cellular forms than the straws of oats, wheat, rice, etc., and for this reason are not so well adapted to certain purposes. It may be said, however, that as the high percentage of cellular cellulose gives that property of "wetness" required in certain cases, and only obtained from the better known materials by prolonged beating at great expense, the former may, with better knowledge of the use of materials for definite purposes, be used for mixing with long fibers to give strength or hardness. Indeed it seems quite probable that some of the materials now rarely used may later be utilized by mixing with the standard articles to impart special characteristics or to secure certain effects at less cost than is now possible.

Many years ago Routledge demonstrated that bamboo, which from the paper-making point of view may be classed with straw, is well suited for making papers of medium quality like those produced from wood. Later work has confirmed this conclusion, but the material even in subtropical countries, where it grows luxuriantly and where labor is cheap, is used but little, and it is evident that the cost of standard materials must rise higher before bamboo will play any extensive part in paper making. The large annual growth of bamboo has called attention to it as a suitable plant to grow especially for paper-making purposes, but while bamboos are successfully grown in this country it seems probable that a more extended use of the native-grown crop will precede its cultivation for making paper in this country, particularly as long as a greater profit can be made per acre from other crops.

Bast Fibers.

Waste Flax Fiber.—In the Northern Central States, chiefly in Michigan, Minnesota, and the Dakotas, about 3,000,000 acres of flax are grown annually, practically all for the seed, while the straw is allowed to rot or is burned in the fields. One ton of this straw will yield about 400 pounds of fiber—that is, at the rate of 1 ton of straw per acre, 600,000 tons of fiber suitable for making 480,000 tons of strong, high-quality paper. Small quantities of straw are now being delivered to the tow mills at from $2.50 to $3 per ton, and doubtless practically all of it can be secured at $5 or $6 per ton. As the fiber is one of the best paper-making materials, it is, even at the highest mentioned price, a cheaper raw material for strong wrapping paper than old manila and hemp rope, and if it can be obtained free of the seed, which when present produces grease spots in the paper, the fiber will command even a higher price for fine white paper. Commercially, the presence of seed has been a difficulty in the utilization of the fiber for fine papers.

Malbon or Malva Castilla Fiber.—Another bast fiber which may be mentioned is that of *malbon* or *malva castilla*, a plant which grows wild over large areas from southern California to southwestern Mexico, and is used by the Indians in making cordage, ropes, and coarse fabrics. Examination of this fiber in the laboratory indicates that it will yield about 60 per cent of pulp. The individual fibers are from 0.75 to 6 millimeters long, averaging 2 millimeters, and are suitable for making a strong white paper.

Miscellaneous Wastes.

Other materials which have become prominent

enough to receive mention are cotton and tobacco stalks, agricultural wastes occurring in large quantities in the Southern States. Low-grade tissue and common wrapping papers have been made from these sources. The fiber from these materials is from 0.4 to 3¼ millimeters long, averaging 1¼ millimeters, while the yield of paper is approximately 40 per cent. Owing to the fact that the yields of these materials per acre is small, that they are widely distributed over large areas, and that the former is never brought together in harvesting the cotton crop, the cost of gathering and transporting them to the mills would probably be greater than for many other materials, such as the cereal straws, forest wastes, or flax straw, though at the same price per ton the raw material for a ton of paper costs approximately the same for all of these wastes. It is probable, therefore, that they will not find extended use until more economical materials have been exhausted, unless, indeed, it can be shown that in limited areas they can be employed for local markets more economically than paper made from other materials and transported to those markets.

Beet pulp from which the sugar has been extracted has been suggested as a paper-making material, but as this substance possesses practically no fiber, it is not suitable for this purpose.

(To be concluded.)

# A BRIEF HISTORY OF WIRELESS TELEGRAPHY.*

## MILESTONES IN THE EVOLUTION OF A NEW ART.

BY R. A. FESSENDEN.

Continued from Supplement No. 1723, page 19.

(*b*) *Methods of Obtaining Sustained Oscillations. 1. Spark-gap and Local Oscillatory or "tank" Circuit.*—Prof. Elihu Thomson discovered that by using a transformer without an iron core (the well-known Elihu Thomson air-core transformer, later used by Tesla and others), and a spark-gap and condenser in the primary circuit and with the secondary circuit suitably tuned great resonant rises of potential could be obtained. In 1892 he constructed such a transformer giving discharges 64 inches long.[30]

The same method was later used by Tesla[31] in his experimental researches and in his attempt to carry out Loomis's[32] method of transmitting a current through a hypothetical conducting stratum in the upper regions of the atmosphere.

The device, suitably modified for wireless telegraphic purposes, so as to give instead of a continuously cumulative rise of potential an initial rise of potential followed by a gradual feeding in of the energy from the local circuit to supply the energy lost from radiation, was made use of in 1898 for the purpose of producing prolonged trains of sustained waves.

Various types of connection between the antenna and the local oscillatory circuit were tested but it was found that the most efficient results were obtained by connecting the local circuit directly across the spark-gap.[33]

The results of some comparative tests are here given. The figures in the column "A" are for the local circuit connected directly to the terminals of the spark-gap, those in column "B" are for an auto-transformer, those in column "C" for a loose coupled primary and secondary.

| | A | B | C |
|---|---|---|---|
| Frequency | 212,000 | 212,000 | 212,000 |
| Tank capacity | 0,072 m. f. | 0,072 m. f. | 0,072 m. f. |
| Kilowatt output dynamo | 30 | 30 | 30 |
| Tank current | 400 amperes | 350 amperes | 300 amperes |
| Antenna current | 48.5 | 46.0 | 48.0 |

The large station at Brant Rock is operated with the local circuit directly connected across the spark-gap, partly because the efficiency is somewhat greater, but also on account of the great simplification of connections and the fact that the degree of sustainment

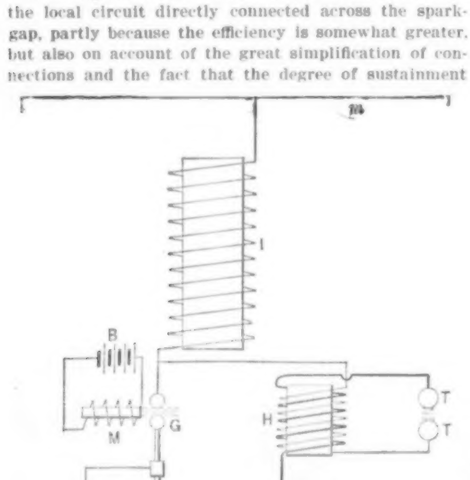



FIG. 1.

of the wave train may be adjusted very simply, if desired, by sliding the lower terminal of the antenna along a few inches of the lead of the local oscillatory circuit.

Cooper Hewitt[34] in 1902 used a modification of his mercury lamp to obtain intermittent discharges each followed by a train of high frequency oscillations.

2. *Arc methods.*—The worker with high frequency oscillatory currents will soon discover that we are indebted to the genius of Prof. Elihu Thomson for practically every device of any importance in this art.

The method of producing high frequency oscillations from an arc and continuous current was discovered

FIG. 2.

by him in 1892.[35] Fig. 1, taken from his patent, shows the general form of his arrangement. If the directions given in the specification are followed no difficulty will be met with in obtaining frequencies as high as 50,000 per second.

Between 1900 and 1902 some experiments were carried out with the Elihu Thomson arc as a source of high frequency oscillations for wireless telegraphy and telephony.

Some difficulties were found; for example, the arc could not be started and stopped as quickly as was necessary for telegraphic purposes and the intensity of the oscillations and their frequency varied considerably. These were overcome by making some minor improvements; for example, the difficulty in sending was overcome by permitting the arc to run continuously and using the key to change the electrical constants of the circuits.[36] The difficulty in keeping the intensity and frequency constant was overcome by substituting resistance for a portion of the inductance, and also by using the arc under pressure.[37]

Tests made by Dr. Austin[38] show that with this method frequencies as high as 3,000,000 per second and efficiencies as high as 60 per cent can be obtained together with an absolutely steady generation of the high frequency currents and an absence of harmonic frequencies.

3. *High frequency alternator.*—The first high frequency alternator was built by Prof. Elihu Thomson in 1889.[39] And it was while experimenting with it in 1900 that Dr. Tatum made his very interesting discovery that high frequency currents of large amperage could be passed through the body without injury.[40]

From 1898 to 1900 numerous experiments were made on antennæ of large capacity, and it was found that instead of using sheets of solid metal or wire netting, single wires could be placed at a considerable fraction of the wave-length apart and yet give practically the same capacity effect as if the space between them were filled with solid conductors.

From other investigations on the variation of radiation with frequency the result was arrived at that it should be possible to construct an alternating-current dynamo of sufficiently high frequency and output to give ample radiation for wireless telegraphic purposes.[41]

In 1900 a large American electrical manufacturing company kindly consented to take up the construction of such a dynamo. As a preliminary, a dynamo of 1 kilowatt output and 10,000 cycles (shown in Fig. 2) was built in 1902. By the summer of 1906 many of the difficulties had been overcome and a machine giving 50,000 cycles was installed at the Brant Rock station. Various improvements were made by the writer's assistants, and in the fall of 1906 the dynamo was working regularly at 75,000 cycles, with an output of half a kilowatt, and was being used for telephoning to Plymouth, a distance of approximately 11 miles. In the following year machines were constructed having a frequency of 100,000 cycles per second and outputs of 1 and 2 kilowatts.

The credit for the development of this machine is due to Messrs. Steinmetz, Haskins, Alexanderson, Dempster, and Geisenhoner, and also to the writer's assistants, Messrs. Stein and Mansbendel.

(*c*) *Closed tuned circuits.*—In 1898 the open tuned circuits originally used were discarded for closed tuned circuits[42] and it was discovered that valuable selective effects could be obtained by placing the condenser in shunt to the inductance instead of in series with it.[43]

(*d*) *Combination of wave and group tuning.*—The fact that if selectivity is obtained solely by tuning to wave frequencies, the number of stations is limited, was appreciated at an early date. In 1900[44] a new method was developed, the stations being tuned both to the wave frequency and to an independent or group frequency, so that stations might obtain selectivity by varying either the wave or the group frequency and thus have at their disposal a virtually unlimited number of combinations and be practically free from atmospheric disturbances. Fig. 4 shows a type of group tuner.

(*b*) *Further development of damped wave-coherer*

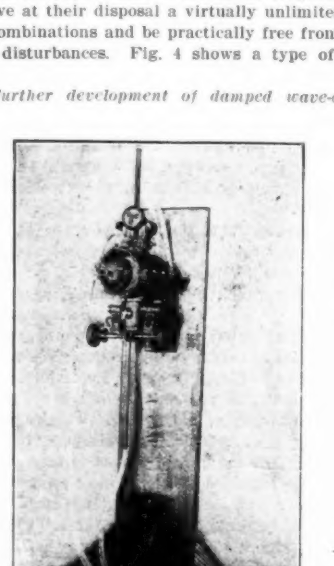


FIG. 3.

*method.*—Marconi by 1898 had carried the development of the filings coherer to its maximum point.

Lodge in 1897[45] had disclosed the open secondary circuit for receiving.



[30] Electrical World, Feb. 20 and 27, 1892.

[31] U. S. patent 645,516, Sept. 2, 1897.

[32] Loomis, U. S. patent, 129,971, July 30, 1872.

[33] U. S. patents 706,735 and 706,736, Dec. 15, 1899.

[34] Cooper Hewitt, U. S. patent 780,999, April 25, 1902.

[35] Elihu Thomson, U. S. patent 500,630, July 18, 1892.

[36] U. S. patents 706,742, July 6, 1902; 706,747, Sept. 28 1901; 727,330, March 21, 1903; 730,753, April 9, 1903.

[37] Ibid and U. S. patent 706,741.

[38] Austin, Bulletin of the Bureau of Standards, vol. 3, No. 2.

[39] Thomson, Elec. Engineer, July 30, 1890, and London Elec., Sept. 12, 1890.

[40] Thomson, Elec. Engineer, March 11, 1891.

[41] U. S. patent 706,737, May 29, 1901.

[42] U. S. patents 706,735 and 706,736, Dec. 15, 1899.

[43] Ibid.

[44] U. S. patents 727,325, June 2, 1900, and 727,330, March 21, 1903.

[45] Lodge, Great Britain patent 11,575, May 10, 1897.

Marconi in 1898[46] greatly improved this by adjusting the length of the secondary so as to tune it, and by the aid of this improvement was enabled to telegraph a distance of 35 miles[47] in October, 1899.

Lodge in 1902[48] invented what is perhaps the most perfect form of coherer, consisting of a thin steel disk dipping in oil-covered mercury and automatically decohered by being kept in continuous rotation.

A number of self-restoring coherers of which the Brown[49] carbon coherer may be taken as a type, including the mercury carbon coherer of Solari, came into more or less extended use, and also modifications of the imperfect contact receiver of Neugschwender.[50]

The small progress made along these lines is to be explained by the fact that the damped wave-coherer system is essentially and fundamentally incapable of development into a practical system.

(To be concluded.)

## THE LOW-PRESSURE STEAM TURBINE AND ITS ECONOMICAL UTILIZATION.

By CHARLES B. BURLEIGH.

WHILE the reciprocating steam engine is comparatively a highly efficient piece of apparatus for utilizing the available energy of steam between boiler pressure and atmospheric pressure, it is relatively inefficient for utilizing the available energy of the steam in its lower ranges, below atmospheric pressure.

On the other hand, the supremacy gained by the steam turbine has been largely due to the fact that it as efficiently utilizes the available energy of steam in the lower pressure ranges as in the higher, and as there is as much available energy in steam below the atmospheric line as above it, we are led to the investigation of the results to be obtained from the use of the reciprocating unit in its most profitable field (the higher pressure ranges), combined with the turbine for the most efficient transformation of the lower pressure ranges.

Each expansion of a given weight of steam means equal available energy; or, in other words, each time the volume is doubled the energy step is equal, and the expansion from 15 to 7.5 pounds represents as much work as from 120 to 60. Steam expanded from 1.87 pounds to 0.234 pound represents as much work as when expanded from 120 to 15 pounds; further, as there are six expansions below the atmospheric line as compared with but three expansions above, if we can as efficiently use these, it will be possible to derive as much benefit in work from the lower ranges of diagram as from the higher ranges, if not more.

A piston, to effectually use the energy of the sixth expansion, must necessarily present an area sixty-four times greater than that which economically utilizes the energy of the first expansion.

Here we have only expanded our steam to a little less than two pounds absolute. Continuing our expansion to one-quarter pound absolute, at 29.5 inches vacuum, we find that we have increased its volume approximately 512 times.

Therefore, it will at once be seen that the reciprocating engine is totally unfitted for deriving anywhere near full benefit from these lower ranges.

For example, if a piston 12 inches in diameter efficiently utilized the energy of the first expansion, one of approximately 22.6 inches in diameter would be required for the ninth expansion, for the same relative efficiency. You will at once appreciate the fact that these conditions are prohibitive. For these reasons, until the advent of the steam turbine, it was not good engineering to attempt to benefit from the low-pressure ranges.

The low-pressure turbine is designed to take steam at 1 pound gage pressure and efficiently utilize its energy to within ½ pound absolute pressure, or, in other words, to a 29-inch vacuum, with water rates of from 30 to 50 pounds per kilowatt hour at the switchboard, depending upon size and local conditions.

The low-pressure turbine can be advantageously applied in any case where reciprocating engines are now used, and such application will always afford a large improvement in economy, and increase the power output without an increase of boiler plant.

This applies in any case, whether engines are now operated condensing or non-condensing, delivering their output electrically or mechanically; and it also applies to engines which operate on intermittent loads, since the delivery of low-pressure steam can be equalized by suitable steam regenerating apparatus.

In many existing plants engines are operated non-condensing because cooling water is not conveniently available.

Such practice may be legitimate with reciprocating engines, because the gain by condensation with engines is comparatively small and, in many cases, may not pay for the additional complication and expense incident to the installation and operation of cooling towers or condensers.

If low-pressure turbines are used, however, we can expect to obtain about as much power from the turbine working below atmosphere as we do from the engine working above atmosphere, and there can be no question as to the economy of installing condenser

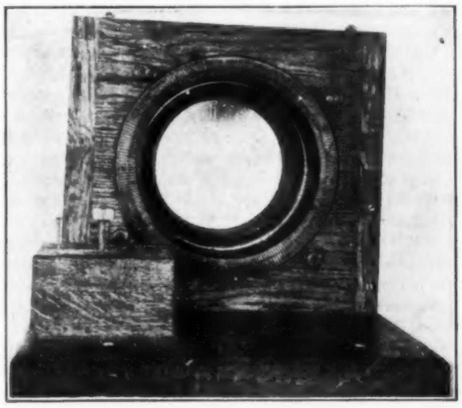


FIG. 4A.

facilities and low-pressure turbines, even where cooling towers are required.

There are already in existence plants where low-pressure turbines have been installed in connection with engines previously used non-condensing, and by such installation, in conjunction with cooling towers, the output of the plant has been practically doubled without any addition to fuel consumption or attendance. Permit me to be specific in this statement, and cite a 1,000-horse-power non-condensing engine plant operating 3,000 hours per year, with a fuel consumption of 2.5 pounds of coal per horse-power hour, or 3,750 short tons of coal per year.

By the addition of a 1,000-horse-power low-pressure turbine, with a suitable cooling tower made necessary by local conditions, and capable of maintaining a 28-inch vacuum, the plant was made to deliver 2,000 horse-power 3,000 hours per year, with 1.25 pounds of fuel per horse-power hour, or 3,750 short tons of coal per year. The plant, doubled in output, required no addition to the boiler equipment, nor was any additional labor made necessary.

The most ready field for the introduction of low-pressure turbines is found in existing condensing plants which operate with reciprocating engines. In such plants immense gains can be accomplished by the use of low-pressure turbines either with existing condensers or with improved condensing facilities. The gain by high vacuum in turbines is so much greater than in engines that it will generally be worth while to install condensing facilities, including the pumps, of the most improved kind. Where low-pressure turbines are installed, the exhaust pressure of engines will be above the atmosphere. There will, therefore, be no air leakage around piston rods and valve stems, and it will be possible to maintain a better degree of vacuum than that which is generally experienced in condensing engine plants, where there is more or less leakage of air, and but little encouragement for the production of high vacuum.

The possibilities of the low pressure will be more readily understood if we consider the available work in different ranges of steam pressure. If saturated steam operates from a pressure of 150 pounds gage to a pressure of 1 pound above the atmosphere, the available energy is about 132,000 foot-pounds per pound; and if saturated steam operates from a pressure of 1 pound of steam above the atmosphere to a vacuum of 28½ inches, the available energy is 146,000 foot-pounds per pound of steam. In a mixture of steam and water issuing from an ordinary steam engine, exhausting at a pressure of 1 pound above the atmosphere, the available energy is reduced to about 132,000 foot-pounds per pound when working to a vacuum of 28½ inches. Thus, under these very ordinary conditions, there is as much work available in the low-pressure ranges as in the high.

In most condensing engines the gain over non-condensing conditions does not exceed 30 per cent, even under the most favorable conditions of load; and under overload conditions the gain by condensing is much smaller. In most cases a reciprocating engine, when operated non-condensing, will give at least 75 per cent of the output for the same steam as when used condensing. This steam, if exhausted into a low-pressure turbine with good condensing facilities, will produce nearly if not quite as much work as the high-pressure steam in the engine. Therefore, under ordinary conditions, a net gain of 100 per cent over existing condensing engine service can be had by installed low-pressure turbines; and under overload conditions, where the efficiency of the engine falls off, and where its gain by vacuum is greatly diminished, the advantages will be much greater.

Immense benefit can be derived from the use of low-pressure turbines in mechanically operated manufacturing plants. Take, for instance, a mill or other manufacturing establishment mechanically operated by means of belts or ropes, where an increase is desirable, and either due to the shape or position of land available, this addition cannot be economically or satisfactorily reached by belting and shafting; the low-pressure turbine offers an ideal solution of the problem, permitting the electrical operation of the sections which are awkward to reach mechanically.—Condensed from the General Electric Review.

**A chimney** of unprecedented size, built at the smelter plant of the Boston & Montana Consolidated Copper and Silver Mining Company, near Great Falls, Montana, is described by the Engineering News. It is 506 feet high above the top of the foundation ring and 50 feet in interior diameter at the top. It is the highest in the world by about 40 feet, and the highest in the United States by 140 feet, the Eastman Kodak chimney being 366 feet high, and the Orford Copper Company's chimney being 365 feet. The weight of the stack is between 17,000 and 18,000 tons. Its discharge capacity is 4,000,000 cubic feet of gases per minute, with a draft of 3¾ inches water expected with gases at 600 deg. F. average. The height was governed solely by the draft requirements and not by the desideratum of discharging high enough in the air to prevent creation of a nuisance. This latter requirement is met by the existing stack, which is but 186 feet high, the city of Great Falls being 500 feet lower than the tableland and the valley bottom 250 to 300 feet lower.

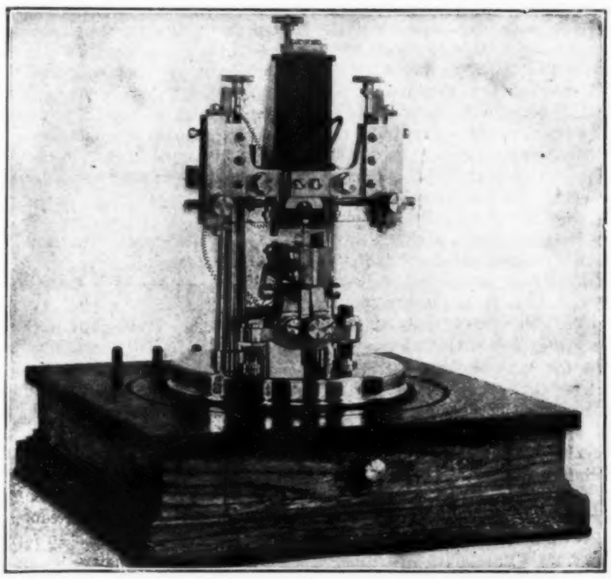


FIG. 4.

[46] Marconi, Great Britain patent 12,326, June 1, 1898.

[47] Official report U. S. Navy of test U. S. S. Massachusetts, October, 1899.

[48] Lodge, Muirhead, and Robinson Great Britain patent 13,521, June 14, 1902.

[49] Brown and Neilson, Great Britain patent 28,955, Dec. 17, 1896.

[50] A. Neugschwender, Wied. Ann. der Physik, 1899, vol. 67, p. 430.

enough to receive mention are cotton and tobacco stalks, agricultural wastes occurring in large quantities in the Southern States. Low-grade tissue and common wrapping papers have been made from these sources. The fiber from these materials is from 0.4 to 3¾ millimeters long, averaging 1¼ millimeters, while the yield of paper is approximately 40 per cent. Owing to the fact that the yields of these materials per acre is small, that they are widely distributed over large areas, and that the former is never brought together in harvesting the cotton crop, the cost of gathering and transporting them to the mills would probably be greater than for many other materials, such as the cereal straws, forest wastes, or flax straw, though at the same price per ton the raw material for a ton of paper costs approximately the same for all of these wastes. It is probable, therefore, that they will not find extended use until more economical materials have been exhausted, unless, indeed, it can be shown that in limited areas they can be employed for local markets more economically than paper made from other materials and transported to those markets.

Beet pulp from which the sugar has been extracted has been suggested as a paper-making material, but as this substance possesses practically no fiber, it is not suitable for this purpose.

(To be concluded.)

# A BRIEF HISTORY OF WIRELESS TELEGRAPHY.*

## MILESTONES IN THE EVOLUTION OF A NEW ART.

BY R. A. FESSENDEN.

Continued from Supplement No. 1723, page 19.

(*b*) *Methods of Obtaining Sustained Oscillations. 1. Spark-gap and Local Oscillatory or "tank" Circuit.*—Prof. Elihu Thomson discovered that by using a transformer without an iron core (the well-known Elihu Thomson air-core transformer, later used by Tesla and others), and a spark-gap and condenser in the primary circuit and with the secondary circuit suitably tuned great resonant rises of potential could be obtained. In 1892 he constructed such a transformer giving discharges 64 inches long.[20]

The same method was later used by Tesla[21] in his experimental researches and in his attempt to carry out Loomis's[22] method of transmitting a current through a hypothetical conducting stratum in the upper regions of the atmosphere.

The device, suitably modified for wireless telegraphic purposes, so as to give instead of a continuously cumulative rise of potential an initial rise of potential followed by a gradual feeding in of the energy from the local circuit to supply the energy lost from radiation, was made use of in 1898 for the purpose of producing prolonged trains of sustained waves.

Various types of connection between the antenna and the local oscillatory circuit were tested but it was found that the most efficient results were obtained by connecting the local circuit directly across the spark-gap.[23]

The results of some comparative tests are here given. The figures in the column "A" are for the local circuit connected directly to the terminals of the spark-gap, those in column "B" are for an auto-transformer, those in column "C" for a loose coupled primary and secondary.

| | A | B | C |
|---|---|---|---|
| Frequency .......... | 212,000 | 212,000 | 212,000 |
| Tank capacity.......... | 0.072 m. f. | 0.072 m. f. | 0.072 m. f. |
| Kilowatt output dynamo | 30 | 30 | 30 |
| Tank current.......... | 400 amperes | 370 amperes | 300 amperes |
| Antenna current.......... | 48.5 | 46.0 | 48.0 |

The large station at Brant Rock is operated with the local circuit directly connected across the spark-gap, partly because the efficiency is somewhat greater, but also on account of the great simplification of connections and the fact that the degree of sustainment of the wave train may be adjusted very simply, if desired, by sliding the lower terminal of the antenna along a few inches of the lead of the local oscillatory circuit.

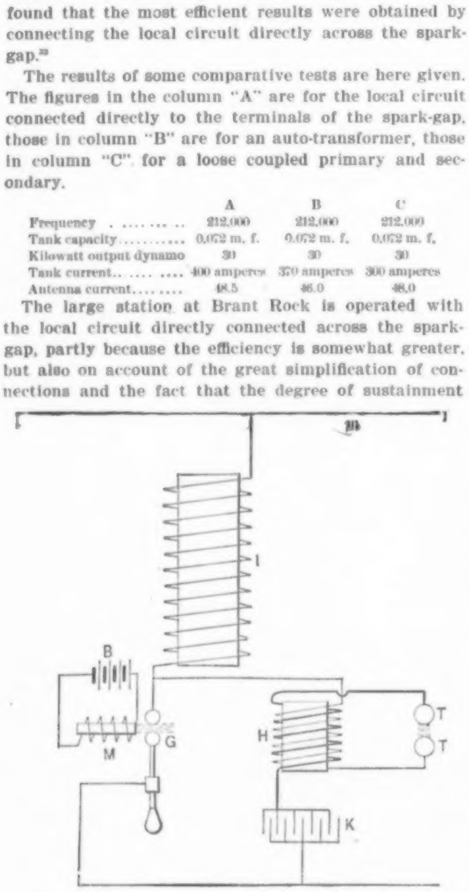



FIG. 1.

Cooper Hewitt[24] in 1902 used a modification of his mercury lamp to obtain intermittent discharges each followed by a train of high frequency oscillations.

2. *Arc methods.*—The worker with high frequency oscillatory currents will soon discover that we are indebted to the genius of Prof. Elihu Thomson for practically every device of any importance in this art.

The method of producing high frequency oscillations from an arc and continuous current was discovered by him in 1892.[25] Fig. 1, taken from his patent, shows the general form of his arrangement. If the directions given in the specification are followed no difficulty will be met with in obtaining frequencies as high as 50,000 per second.

FIG. 2.

Between 1900 and 1902 some experiments were carried out with the Elihu Thomson arc as a source of high frequency oscillations for wireless telegraphy and telephony.

Some difficulties were found; for example, the arc could not be started and stopped as quickly as was necessary for telegraphic purposes and the intensity of the oscillations and their frequency varied considerably. These were overcome by making some minor improvements; for example, the difficulty in sending was overcome by permitting the arc to run continuously and using the key to change the electrical constants of the circuits.[26] The difficulty in keeping the intensity and frequency constant was overcome by substituting resistance for a portion of the inductance, and also by using the arc under pressure.[27]

Tests made by Dr. Austin[28] show that with this method frequencies as high as 3,000,000 per second and efficiencies as high as 60 per cent can be obtained together with an absolutely steady generation of the high frequency currents and an absence of harmonic frequencies.

3. *High frequency alternator.*—The first high frequency alternator was built by Prof. Elihu Thomson in 1889.[29] And it was while experimenting with it in 1900 that Dr. Tatum made his very interesting discovery that high frequency currents of large amperage could be passed through the body without injury.[30]

From 1898 to 1900 numerous experiments were made on antennæ of large capacity, and it was found that instead of using sheets of solid metal or wire netting, single wires could be placed at a considerable fraction of the wave-length apart and yet give practically the same capacity effect as if the space between them were filled with solid conductors.

From other investigations on the variation of radiation with frequency the result was arrived at that it should be possible to construct an alternating-current dynamo of sufficiently high frequency and output to give ample radiation for wireless telegraphic purposes.[41]

In 1900 a large American electrical manufacturing company kindly consented to take up the construction of such a dynamo. As a preliminary, a dynamo of 1 kilowatt output and 10,000 cycles (shown in Fig. 2) was built in 1902. By the summer of 1906 many of the difficulties had been overcome and a machine giving 50,000 cycles was installed at the Brant Rock station. Various improvements were made by the writer's assistants, and in the fall of 1906 the dynamo was working regularly at 75,000 cycles, with an output of half a kilowatt, and was being used for telephoning to Plymouth, a distance of approximately 11 miles. In the following year machines were constructed having a frequency of 100,000 cycles per second and outputs of 1 and 2 kilowatts.

The credit for the development of this machine is due to Messrs. Steinmetz, Haskins, Alexanderson, Dempster, and Geisenhoner, and also to the writer's assistants, Messrs. Stein and Mansbendel.

(*c*) *Closed tuned circuits.*—In 1898 the open tuned circuits originally used were discarded for closed tuned circuits[42] and it was discovered that valuable selective effects could be obtained by placing the condenser in shunt to the inductance instead of in series with it.[43]

(*d*) *Combination of wave and group tuning.*—The fact that if selectivity is obtained solely by tuning to wave frequencies, the number of stations is limited, was appreciated at an early date. In 1900[44] a new method was developed, the stations being tuned both to the wave frequency and to an independent or group frequency, so that stations might obtain selectivity by varying either the wave or the group frequency and thus have at their disposal a virtually unlimited number of combinations and be practically free from atmospheric disturbances. Fig. 4 shows a type of group tuner.

(*b*) *Further development of damped wave-coherer*

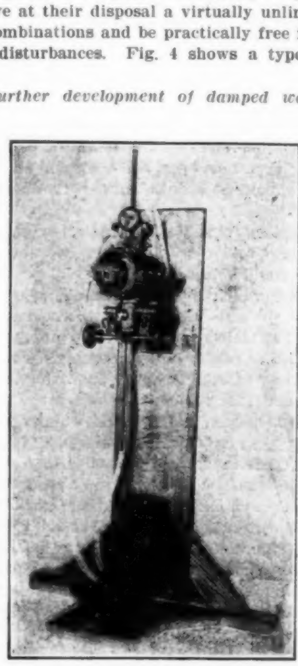


FIG. 3.

*method.*—Marconi by 1898 had carried the development of the filings coherer to its maximum point.

Lodge in 1897[45] had disclosed the open secondary circuit for receiving.



[20] Electrical World, Feb. 20 and 27, 1892.

[21] U. S. patent 645,516, Sept. 2, 1897.

[22] Loomis, U. S. patent, 129,971, July 30, 1872.

[23] U. S. patents 706,735 and 706,736, Dec. 15, 1899.

[24] Cooper Hewitt, U. S. patent 780,999, April 25, 1902.

[25] Elihu Thomson, U. S. patent 500,630, July 18, 1892.

[26] U. S. patents 706,742, July 6, 1902; 706,747, Sept. 28, 1901; 727,330, March 21, 1903; 730,753, April 9, 1903.

[27] Ibid and U. S. patent 706,741.

[28] Austin, Bulletin of the Bureau of Standards, vol. 3, No. 2.

[29] Thomson, Elec. Engineer, July 30, 1890, and London Elec., Sept. 12 1890.

[30] Thomson, Elec. Engineer, March 11, 1891.

[41] U. S. patent 706,737, May 29, 1901.

[42] U. S. patents 706,735 and 706,736, Dec. 15, 1899.

[43] Ibid.

[44] U. S. patents 727,325, June 2, 1900, and 727,330, March 21, 1903.

[45] Lodge, Great Britain patent 11,575, May 10, 1897.

Marconi in 1898[46] greatly improved this by adjusting the length of the secondary so as to tune it, and by the aid of this improvement was enabled to telegraph a distance of 35 miles[47] in October, 1899.

Lodge in 1902[48] invented what is perhaps the most perfect form of coherer, consisting of a thin steel disk dipping in oil-covered mercury and automatically decohered by being kept in continuous rotation.

A number of self-restoring coherers of which the Brown[49] carbon coherer may be taken as a type, including the mercury carbon coherer of Solari, came into more or less extended use, and also modifications of the imperfect contact receiver of Neugschwender.[50]

The small progress made along these lines is to be explained by the fact that the damped wave-coherer system is essentially and fundamentally incapable of development into a practical system.

(To be concluded.)

[46] Marconi, Great Britain patent 12,326, June 1, 1898.

[47] Official report U. S. Navy of test U. S. S. Massachusetts, October, 1899.

[48] Lodge, Muirhead, and Robinson Great Britain patent 13,521, June 14, 1902.

[49] Brown and Neilson, Great Britain patent 28,955, Dec. 17, 1896.

[50] A. Neugschwender, Wied. Ann. der Physik, 1899, vol. 67, p. 430.

## THE LOW-PRESSURE STEAM TURBINE AND ITS ECONOMICAL UTILIZATION.

By CHARLES B. BURLEIGH.

WHILE the reciprocating steam engine is comparatively a highly efficient piece of apparatus for utilizing the available energy of steam between boiler pressure and atmospheric pressure, it is relatively inefficient for utilizing the available energy of the steam in its lower ranges, below atmospheric pressure.

On the other hand, the supremacy gained by the steam turbine has been largely due to the fact that it as efficiently utilizes the available energy of steam in the lower pressure ranges as in the higher, and as there is as much available energy in steam below the atmospheric line as above it, we are led to the investigation of the results to be obtained from the use of the reciprocating unit in its most profitable field (the higher pressure ranges), combined with the turbine for the most efficient transformation of the lower pressure ranges.

Each expansion of a given weight of steam means equal available energy; or, in other words, each time the volume is doubled the energy step is equal, and the expansion from 15 to 7.5 pounds represents as much work as from 120 to 60. Steam expanded from 1.87 pounds to 0.234 pound represents as much work as when expanded from 120 to 15 pounds; further, as there are six expansions below the atmospheric line as compared with but three expansions above, if we can as efficiently use these, it will be possible to derive as much benefit in work from the lower ranges of diagram as from the higher ranges, if not more.

A piston, to effectually use the energy of the sixth expansion, must necessarily present an area sixty-four times greater than that which economically utilizes the energy of the first expansion.

Here we have only expanded our steam to a little less than two pounds absolute. Continuing our expansion to one-quarter pound absolute, at 29.5 inches vacuum, we find that we have increased its volume approximately 512 times.

Therefore, it will at once be seen that the reciprocating engine is totally unfitted for deriving anywhere near full benefit from these lower ranges.

For example, if a piston 12 inches in diameter efficiently utilized the energy of the first expansion, one of approximately 22.6 inches in diameter would be required for the ninth expansion, for the same relative efficiency. You will at once appreciate the fact that these conditions are prohibitive. For these reasons, until the advent of the steam turbine, it was not good engineering to attempt to benefit from the low-pressure ranges.

The low-pressure turbine is designed to take steam at 1 pound gage pressure and efficiently utilize its energy to within ½ pound absolute pressure, or, in other words, to a 29-inch vacuum, with water rates of from 30 to 50 pounds per kilowatt hour at the switchboard, depending upon size and local conditions.

The low-pressure turbine can be advantageously applied in any case where reciprocating engines are now used, and such application will always afford a large improvement in economy, and increase the power output without an increase of boiler plant.

This applies in any case, whether engines are now operated condensing or non-condensing, delivering their output electrically or mechanically; and it also applies to engines which operate on intermittent loads, since the delivery of low-pressure steam can be equalized by suitable steam regenerating apparatus.

In many existing plants engines are operated non-condensing because cooling water is not conveniently available.

Such practice may be legitimate with reciprocating engines, because the gain by condensation with engines is comparatively small and, in many cases, may not pay for the additional complication and expense incident to the installation and operation of cooling towers or condensers.

If low-pressure turbines are used, however, we can expect to obtain about as much power from the turbine working below atmosphere as we do from the engine working above atmosphere, and there can be no question as to the economy of installing condenser facilities and low-pressure turbines, even where cooling towers are required.

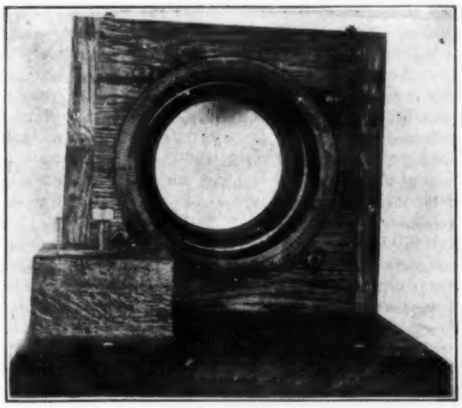


FIG. 4A.

There are already in existence plants where low-pressure turbines have been installed in connection with engines previously used non-condensing, and by such installation, in conjunction with cooling towers, the output of the plant has been practically doubled without any addition to fuel consumption or attendance. Permit me to be specific in this statement, and cite a 1,000-horse-power non-condensing engine plant operating 3,000 hours per year, with a fuel consumption of 2.5 pounds of coal per horse-power hour, or 3,750 short tons of coal per year.

By the addition of a 1,000-horse-power low-pressure turbine, with a suitable cooling tower made necessary by local conditions, and capable of maintaining a 28-inch vacuum, the plant was made to deliver 2,000 horse-power 3,000 hours per year, with 1.25 pounds of fuel per horse-power hour, or 3,750 short tons of coal per year. The plant, doubled in output, required no addition to the boiler equipment, nor was any additional labor made necessary.

The most ready field for the introduction of low-pressure turbines is found in existing condensing plants which operate with reciprocating engines. In such plants immense gains can be accomplished by the use of low-pressure turbines either with existing condensers or with improved condensing facilities. The gain by high vacuum in turbines is so much greater than in engines that it will generally be worth while to install condensing facilities, including the pumps, of the most improved kind. Where low-pressure turbines are installed, the exhaust pressure of engines will be above the atmosphere. There will, therefore, be no air leakage around piston rods and valve stems, and it will be possible to maintain a better degree of vacuum than that which is generally experienced in condensing engine plants, where there is more or less leakage of air, and but little encouragement for the production of high vacuum.

The possibilities of the low pressure will be more readily understood if we consider the available work in different ranges of steam pressure. If saturated steam operates from a pressure of 150 pounds gage to a pressure of 1 pound above the atmosphere, the available energy is about 132,000 foot-pounds per pound; and if saturated steam operates from a pressure of 1 pound of steam above the atmosphere to a vacuum of 28½ inches, the available energy is 146,000 foot-pounds per pound of steam. In a mixture of steam and water issuing from an ordinary steam engine, exhausting at a pressure of 1 pound above the atmosphere, the above available energy is reduced to about 132,000 foot-pounds per pound when working to a vacuum of 28½ inches. Thus, under these very ordinary conditions, there is as much work available in the low-pressure ranges as in the high.

In most condensing engines the gain over non-condensing conditions does not exceed 30 per cent, even under the most favorable conditions of load; and under overload conditions the gain by condensing is much smaller. In most cases a reciprocating engine, when operated non-condensing, will give at least 75 per cent of the output for the same steam as when used condensing. This steam, if exhausted into a low-pressure turbine with good condensing facilities, will produce nearly if not quite as much work as the high-pressure steam in the engine. Therefore, under ordinary conditions, a net gain of 100 per cent over existing condensing engine service can be had by installed low-pressure turbines; and under overload conditions, where the efficiency of the engine falls off, and where its gain by vacuum is greatly diminished, the advantages will be much greater.

Immense benefit can be derived from the use of low-pressure turbines in mechanically operated manufacturing plants. Take, for instance, a mill or other manufacturing establishment mechanically operated by means of belts or ropes, where an increase is desirable, and either due to the shape or position of land available, this addition cannot be economically or satisfactorily reached by belting and shafting; the low-pressure turbine offers an ideal solution of the problem, permitting the electrical operation of the sections which are awkward to reach mechanically.—Condensed from the General Electric Review.

**A chimney** of unprecedented size, built at the smelter plant of the Boston & Montana Consolidated Copper and Silver Mining Company, near Great Falls, Montana, is described by the Engineering News. It is 506 feet high above the top of the foundation ring and 50 feet in interior diameter at the top. It is the highest in the world by about 40 feet, and the highest in the United States by 140 feet, the Eastman Kodak chimney being 366 feet high, and the Orford Copper Company's chimney being 365 feet. The weight of the stack is between 17,000 and 18,000 tons. Its discharge capacity is 4,000,000 cubic feet of gases per minute, with a draft of 3¾ inches water expected with gases at 600 deg. F. average. The height was governed solely by the draft requirements and not by the desideratum of discharging high enough in the air to prevent creation of a nuisance. This latter requirement is met by the existing stack, which is but 186 feet high, the city of Great Falls being 500 feet lower than the tableland and the valley bottom 250 to 300 feet lower.

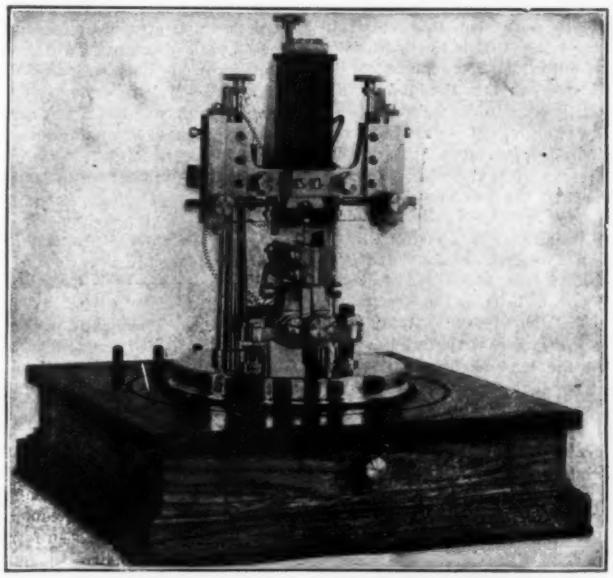


FIG. 4.

# EARTHQUAKES AND VOLCANOES.

## OUR UNSTABLE EARTH.

### BY W. F. STANLEY.

TO UNDERSTAND the principles upon which the earthquakes and volcanoes act to maintain the earth's surface, as we know it, it is necessary to have some knowledge of the constitution of our globe beyond what is visible everywhere upon its surface. In fact, it is necessary to know something of the interior of the earth, so far as external evidence goes. This may be taken quite independently of any fanciful theories. To give us data for this study, the volcano gives us hopeful evidence. We know that a volcano is a vent from the interior of the earth which appears as a hole upon the top of a mountain. When the volcano is active, there is ejected from the vent or crater an immense volume of steam and earthy matter, which, at the time of the eruption, is at a white heat, that is, heat quite sufficiently intense to melt any original rock upon the earth's surface. Now, as the volume of ejected solid matter from a single volcano may amount to as much as a thousand cubic miles, it is therefore clear that a volcano cannot be a surface phenomenon. This gives us evident suggestion that the interior matter of the earth must be in a similar hot state to the lava and other earthy matters ejected from the vent or volcano. Our next business will be to try to find upon an experimental basis what is the probable thickness of the solid earth upon which we walk, above the assumed hot melted matter beneath, and the constitution of the solid earth's surface. Taking, first, the earth's constitution, we find that about 98 per cent of our land surface is formed of the oxides of various elementary matters, principally the metals. If we melt a metal—say, lead—the oxygen of the air combines with it so as to cover it with an oxide or scum. Now, as the earth's surface is mainly formed of oxides, which we presume to rest upon a hot liquid beneath, we may conclude that the whole earth's surface may be a scum. Water is also an oxide of hydrogen, the lightest metal; but, in this case, as the hydrogen melts at a very low temperature, the oxide water is therefore at ordinary temperatures a liquid. All other oxides are liquid at a temperature much above the melting points of the metals of which they are the base, particularly when combined with flint or silicon—an element always present in rocks ejected from a volcano. So that, under like conditions, the earth's surface may be assumed to be solid on the top, cool surface, and a hot liquid beneath. Upon these conditions, broadly, to know the earth's surface we may estimate the properties of scums. We will take one general property—they are lighter than the metals which form their bases. Under this condition, assuming the earth's surface a great scum, this will float upon its matrix, as the primitive matter is termed, so that any movement of the matrix matter beneath will disturb the surface, which rests upon this matrix in the manner of a floating body—that is to say, the surface rests in sensitive equilibrium. Now, to follow the nature of scums, to discover whether the land surface is lighter than the matrix beneath, we have many refined experiments in gravitation. These are quite certain, but are too complex to enter upon here, so that I must ask you to take my word that we know the surface rocks are less than half the specific weight of the matrix beneath, which you will find quite consistent with the land surface, being mainly a metallic scum, floating upon its matrix. We have no doubt that volcanoes eject immense volumes of steam and white-hot earthy matter, and that this is from the swelling-up of the matter from below the surface; yet this does not give us the entire evidence that the interior heat is universal under all the land surface, as, for instance, under our feet, so that for this assertion we must seek other evidence. In this direction we ought to get some practical knowledge in sinking of wells and mines. For if the central mass is white-hot, it is certain that as we sink deeper into the earth, we should find the earth got hotter in proportion, by the natural conduction or spread of heat in all matter. We may examine this. In digging wells and mines all over the world we find a great increase of heat with depth, the average being about 1 deg. F. from near the surface for every 60 feet of depth. This proportion of heat appears to increase with great depth, so that it has been estimated by geologists that at 20 miles in depth every primitive rock upon the earth's surface would be in a melted condition. This scum or crust would, nevertheless, form so thin a skin over our great earth that to represent it upon any diagram I could draw it would appear as an invisible line. In the craters of active volcanoes we know that the thickness of the crust of the earth vanishes altogether. We can walk with little inconvenience, except a hot, oppressive atmosphere, over a great part of the crater of Vesuvius, keeping to the windward side of the open crevasses, wherein we may see the red-hot lava beneath, and dip a stick into it, which instantly inflames, as I did in 1872, and later. So that we may estimate the depth of solid land upon the earth's surface at a varying quantity, say from about 25 miles in depth to nothing, as it appears in the craters of active volcanoes. Some volcanoes are constantly in eruption, as that of Stromboli, which appears as a scumming-pot of red-hot boiling liquid at all times. This boiling pot is constantly filled from below, as it throws out its scum, principally in the form of pumice-stone, upon the sides of the small mountain, and into the Mediterranean Sea. This volcano has continued to throw out earthy matter for more than 3,000 years, appearing from the sea as a burning column by night, and a column of steam by day. It has been called, from the illumination which appears at night, the lighthouse of the Mediterranean. By our data it therefore appears that from actual evidence the interior of the earth is a white-hot liquid mass. This being under universal gravitation, and in rotation, by geometrical laws, the earth takes the form of a flattened globe or "spheroid of revolution," as it is technically termed. Therefore, any parts that are above the outline of this spheroid must be pressing excessively upon the central mass to equilibrium. If any parts are lighter than the mean of the liquid mass, these parts must float upward into the air, and may rise by this cause to be mountains, whose foundations must always sink in depth in the denser liquid matrix beneath until a certain amount of stability is insured. In this sinking, where mountains are elevated, the surrounding planes are sometimes lowered, as I will show, in the lantern, is evident in the case of Vesuvius. This is also evident upon the coast of Greenland, which is constantly sinking as the snow accumulates inland, which altogether shows the sensitiveness of the earth to great local pressures. Without going further into the theory of volcanoes at present, I will show some photographs of Vesuvius, Stromboli, and other volcanoes upon the screen. Of course, when we consider higher volcanic regions, the effects are much greater than that of Vesuvius; but the governing laws appear to be the same. In Cotopaxi, in the Andes, we have a volcano of over three and one-half miles in height, always in an active state. In Kilauea, in the Sandwich Islands, we have an open crater of about eight square miles in extent, in parts always active, the volcanic effect being in all cases that the interior hot matter of the earth is being pressed upward into the air with more or less projectile force. We have evidence that at an earlier period—that is, since the formation of the chalk—it was less common that volcanoes formed mountains. The internal pressure was then more frequently produced by an earthquake upheaval, in which a wide crack was opened in the earth, and the internal pressure was relieved by an outpouring of liquid rock, or basalt. In this manner, a thousand square miles of the earth have been covered with liquid lava, even in Great Britain and Ireland. In the Snake River plain, in Idaho, in America, a surface of land was leveled up larger than Great Britain. In India the lava ejected from a vent or vents covered 200,000 square miles. This shows the enormous interior pressure that exists at times to eject so large an amount of earthy matter from the interior. The relief of the great internal pressure of the interior does not always appear in an outflow upon the surface of the earth, but the lava intrudes itself between the strata of the earth, when one stratum is soft, with hard stone above. In this manner the superimposed matter above the lava has been floated up in some regions even to form ranges of mountains or plateaux, from which occasionally volcanic vents have been formed by pressing their way through disturbed rocks, forming, in the process, by wear, pipes for the escape of the final internal pressures to act as safety-valves until they become loaded with lava to equilibrium with the forces beneath. Volcanoes do not always, or perhaps generally, eject lava. Very frequently they throw upward into the air immense volumes of steam and dust which is dissolved out of the rock through which the condensed steam passes. Thus, Krakatoa, in August, 1883, threw dust upward 2,000 feet into the air, with an immeasurable amount of steam. The quantity of dust was estimated by a German professor by measurement, after the eruption, to equal 22 cubic miles of solid earth. Some of the dust covered a ship 1,000 miles distant from the eruption, a portion of which I examined under the microscope, and found it to be mostly formed of thin bubbles of glass that had evidently been filled with steam, and which burst when the internal pressure was removed in the light air above. The thin glass which appeared in the microscope as broken-up watch glasses, is of only 1/15,000 of an inch in thickness. The volcanic regions of the earth are generally the earthquake regions, so that no doubt the phenomena are intimately connected. But, as I have before stated, the whole surface of the earth being a floating mass, it is in a certain degree unstable. Therefore, an earthquake may occur anywhere where there is internal pressure or strain which overcomes the rigidity of the crust of the earth in the locality. The earth's sensitiveness to internal force is made evident where we have scientific means of measuring such movements of the surface, as I will show presently. We have about sixty seismographs, or earthquake recorders, throughout the world, which record about 30,000 earthquakes yearly, 50 of which are large enough to shake the whole earth. The greatest earthquake that has occurred near here in modern times was that near Colchester, in April, 1884. Upon reading an account of this in the daily paper, I proceeded with my camera two days after. I will show some of the photographs I took at the time, as these illustrate the general effects of earthquakes, which often occur on a much larger scale, as, for instance, that of San Francisco recently. All over the world we have effects of the former presence of the earthquakes in what are termed faults in the stratification of the earth, which are only recognized on the earth's surface as hills and valleys. One general effect is that the earth is shaken and lifted, and that a crack opens somewhere on the land surface; but the crack is not even necessary—the land is often shattered by thousands of small cracks. I will now attempt to tell you what I think is the cause of earthquakes and volcanoes; but I will first mention what I think are two weak prevalent theories. One of these theories, to account for the immense volumes of steam being ejected from all volcanoes, is, that the water is absorbed by porous rocks from the sea and turned into steam, with power to lift miles of rock and liquid lava above. Steam under great pressure has no such power, and any lad who has learned a little physics will tell you that water cannot enter a hot, porous body. Further evidence is shown in that all deep mines are dry if there is not a direct channel for the water to enter. Another weak theory is that mountains, volcanic and otherwise, are caused by the shrinkage of the earth's crust in cooling, which puckers up the land. The cooling of rocks causes very little contraction, and the puckering is everywhere where there has been intrusion of rocks either beneath or sometimes by coming to the surface and pressing the lateral rocks aside. There are further, generally, open cracks in all rocks, from the upward pressure from beneath. A great mathematician (Stokes) calculated from certain data that the cooling of the earth was equal to the melting of 700 cubic miles of ice annually. Upon this, a Mr. Mallet wrote 100 pages of "Our Philosophical Transactions." Feeling certain from the data given that there must be an error in the calculation, I went carefully over the mathematics, and discovered that the error was so great that really there would be less than a single cubic mile, according to the given data. The error I discovered was admitted by the mathematician, and I read a paper upon it before the Geological Society in 1884. But the geologist does not like to be put out with his theory, so it continues. I will now offer my own theory, which you may take for what it is worth. In my opinion, earthquakes and volcanoes are a natural effect of ice continually forming on the poles of the earth, or more particularly at the South Pole, which I will explain. At the commencement of this lecture I balanced a block of ice in these scales, weighing five pounds. The ice has borne the scales down. We will see how much it will require to balance them again. It takes over half an ounce. Now, as we have not added to the water that we find round it, it must have absorbed the extra water from currents of moist air drawn to it in this hall. From this we may understand that, having a very cold region—as for instance, the poles of the earth, or Greenland—the currents of the atmosphere will be drawn toward this, and be deposited in a cold atmosphere as snow. Now, we are quite aware that

* A lecture before the Stanley Athenæum.

this does take place. Capt. Ross, in his Antarctic explorations, passed along 450 miles of ice cliffs hundreds of feet high, which were formed from condensation of snow. Immense icebergs were splitting off the coast, and covered the ocean for thousands of square miles. This effect was from snow falling near the coast, as by experiments we know that ice will not slide down upon itself at a less angle than four degrees. So that if we imagine the four degrees of ice surface to continue toward the South Pole for 1,000 miles from the coast, the ice would reach about 100 miles above the sea-level in the central polar regions. We can easily understand the enormous pressure this would produce upon the yielding earth beneath, assumed to be a liquid mass. If we acknowledge the effects of currents of the atmosphere charged with vapor depositing snow over the polar regions, we may consider the effect of the pressure of the snow by its gravitation upon the matrix of the earth, which we assume to be a white-hot, and probably a metallic mass. Under these conditions, with a hot surface below, and a cold one above, when the ice is pressed down to a certain depth it will be converted into water, which is heaviest at about 39 deg. F. At this stage we can imagine that the water would soon become hotter, and melt more ice. Now, we find ice is one of the worst conductors of heat, so that I can put a piece of ice in boiling water and it appears to take a long time in melting. Therefore, as the ice is melted below, in the polar regions, more ice is pressed down by gravity from above, and the water-line is kept at nearly the same depth from the surface, varying only from summer to winter, with changes that may cause certain fractures in the ice to render the pressures in degree irregular. We may now consider how water is affected by heat and pressure. A French philosopher, Cagniard de Latour, inclosed water in a strong glass tube with a vacuum space above it, and brought the water to a red heat. It was then of about four times its former volume. He then tried a greater heat, but he found that when the water was at a pale red heat, it dissolved the glass tube. This was at a smaller pressure; but under the pressure of many miles of ice as it exists at the South Pole, the hot water would be condensed to much smaller bulk, and at a white heat would dissolve any of the volcanic rocks we know of, as these all contain glass, and, when heated, form a viscid liquid, as all silica compounds do. Now, assuming a constant deposition of snow from winds over the poles to be pressed down by its own weight to form ice at a low temperature until it reaches the heated water beneath, what can become of it? We may imagine that relief of the pressure would take place in the land surface near the polar ice, and this is true to a certain extent, in two volcanoes, Erebus and Terror, near the South Pole; but, generally, the land surface is cooled down near the poles more than at a greater distance, so that the earth's crust becomes thicker, and offers greater resistance than in other regions more distant. The resistance would also be much less upon the floor of the ocean; but this, also, is covered with ice-cold water, from which the earth becomes solid under the ocean to greater depth than upon land surface. Under these conditions, the hot, compressed water I presume to be present finds relief generally at a greater distance from the poles, where the chilling effect upon the earth by surrounding cold is less. The probability then becomes that the water carrying dissolved rocks must spread outward from the poles in channels in every direction that it can find the least resistance in the more viscid lower rocks, and where the least resistance is found. We have, as effects, earthquake displacements or volcanoes. The channels for the outflowing water-rocks or lava cannot be like underground rivers, but must take the form for least resistance by the least surface friction, which must, consequently, be in pipes like the arteries of the body. These, I presume, therefore, branch out in the more viscid fluid-heated lower rocks in any direction where, by local conditions, the friction is less liable to branch out than go straight forward, depending always upon the viscosity or non-dissolubility of the rocks the pipes pass through. When a pipe reaches the surface it forms a volcano. When it spreads out under the surface, the land is elevated with Plutonic effects, and commonly with earthquake phenomena. I anticipate that one Plutonic pipe, which cannot be of less than a quarter of a mile in diameter, flows outward under the extended land from the South Polar area, passes under the ocean to Cape Horn, and hence at a great depth along the entire western coast of South America, the land of which has been elevated for over 1,000 miles to over 500 feet in recent times, and is studded with many volcanoes inland. The local varying resistance by friction in the viscous current does not bring the outflow of volcanoes to uniform height as simple hydraulic pressures would do. In some regions, as that of Hawaii, the outflow of pressure is from two volcanoes, Mauna Loa, over 13,000 feet high, and Kilauea, 4,000 feet high, with only 16 miles distance between them. Kilauea is probably a relief system of pipes from an elevated position in Mauna Loa. Kilauea has one immense crater of one hundred vents. The greater eruptions are from Mauna Loa, which has probably a free pipe 8,000 feet in diameter. This volcano in 1859 ejected a stream of lava that flowed 50 miles in a stream of from one to five miles in width, which continued flowing for two months. In Etna and other volcanoes we have had similar effects of relief by smaller local lower volcanoes. I should like to offer more details, but time presses, so I will return to our opening proposition that we owe to the causes which produce earthquakes and volcanoes the elevation of land above the sea-level. That rain, snow, frosts, and winds are always lowering the higher land surface, which, as an instance, we may note that this is visible to us in every gutter after rain. So that the earth, from this cause alone, in a few millions of years, which is very little in infinite time, would be brought down to a swampy plane, as geological evidence shows that it probably was, many millions of years ago, when reptiles were the highest animals of which we have remains, present in surface rocks. We further know that gold, silver, copper, and other mineral wealth is found in fire rocks, or igneous rocks, as they are termed, which are brought to the surface by upward pressures. It is, therefore, altogether by the lower Plutonic forces that our earth has become beautiful and suitable for intellectual man.

# ASSOCIATION FOR ADVANCEMENT OF SCIENCE.

## THE PROCEEDINGS OF THE BALTIMORE MEETING.

BY WILLIAM H. HALE, PH.D.

The practical application and utilization of science were strong features of the meeting held at Johns Hopkins University in Baltimore, Md., the latter part of December, 1908, a notable one being that of the joint session of the Economic Section of the Association and the American Health League, itself a child of this section, and now numbering 23,000 members. In his address Prof. Irving Fisher of Yale, who presided, spoke on the Progress of the Movement for Health Reform, stating that Massachusetts was the only State in the Union that presented statistics from which to judge of the increase in the length of human life, and these statistics show that longevity increases fourteen years in a century; i. e., people now live that much longer than they did a century ago. In Germany the rate is twenty-seven years of increase in a century. At the same joint meeting Dr. Harvey W. Wiley discussed the good already accomplished by the food and drugs act, and stated that in the two years since that act went into effect, there has been a notable improvement in the health of the community. Dr. Leland O. Howard read some extracts from an elaborate treatise on the Economic Loss to the People of the United States Through Insects that Carry Disease, dwelling especially on malaria and yellow fever conveyed by mosquitoes and typhoid by the common housefly, or as he now prefers to name it, the "typhoid" fly. Horace Fletcher of New York, "the apostle of mastication," read a paper on Vital Economics, in which he announced that his theory, now so well known and so eminently successful in his own as well as in many other cases, of health by thorough mastication of solid and slow sipping of liquid foods, would soon receive a practical test on a large scale in model tenements which Mr. Phillips is now erecting on East 31st Street, between First and Second Avenues, New York, where it would be possible for two persons to enjoy all the comforts of life, a pleasant home, and ample palatable food at the cost of $3 each per week. Surgeon-General Walter Wyman closed the symposium with a paper on Public Health Administration.

There were many hundreds of papers presented in other sections that to briefly reproduce would occupy more than the restricted space in these columns.

The Economic Section also furnished much pithy matter at its other sessions, notably that on Stock Exchange Regulation, where Henry Clews in his paper on Speculation and Investment threw a bomb into the section by his dictum that "speculation is a science"; adding that the stock speculator is not a gambler, but an economic worker and a public benefactor, aiding as he does to make always marketable the securities dealt in on the Stock Exchange. It was unfortunate that Mr. Clews had to return to New York before the ensuing discussion, for Henry Farquhar, an old member of the section, at once controverted these statements. Mr. Farquhar and I usually pull together, but I could not help expressing my delight in the concurrence with the position taken by Mr. Clews, in which I was sustained by the following remarks of Prof. Fisher as chairman of the meeting.

Eugene Meyer, in a carefully elaborated study of the Stock Exchange and the panic of 1907, proved apparently to the satisfaction of everyone present that the New York Stock Exchange was not responsible for this panic, inasmuch as the liquidation on the Stock Exchange had been completed in the spring of that year, and the real cause of the panic was the undue expansion of outside credits, largely due to locking up of capital in excessive building operations or otherwise putting it into solid instead of liquid investments, i. e., those which could be readily converted into cash.

In discussing this paper, Prof. Fisher propounded his own theory of the underlying cause of present panic conditions, namely, the continued depreciation of the gold standard, due to great increase in the world's stock; and, replying to my inquiry as to the outlook, he expressed the belief that the recent panic would be followed by others, just as was that of 1857, due to a similar depreciation of gold following the great influx from California and elsewhere.

### ACETONE GAS FOR LIGHTHOUSES.

In reply to instructions, Consul-General Edward L. Adams, of Stockholm, has forwarded a series of published official statements relative to the gas-accumulator system for lighthouses, beacons, and buoys, from which the following extracts are given, the whole series being on file in the Bureau of Manufactures.

The following extract is taken from the report of the pilotage board, Sweden:

"In 1904 the development of dissolved acetylene was taken up by a new company, and the defects in the apparatus manufactured by the anterior company were removed. Mr. Dalén invented his patented flashlight apparatus, through which flashing light can be produced and the period of lighting of a buoy multiplied by the same gas store. Already in 1905 the experimental buoy of the pilotage board, as well as a large light buoy placed at the disposal of the board by the company, were laid out in Kalmarsund, both of them showing fixed light. In the following year the two buoys were fitted with the Dalén flasher and functioned satisfactorily. In 1907 one light buoy was placed at Great Middelgrund, in the Cattegat, and two light buoys south of the lighthouse of Holmögadd, the gas store of the former being sufficient for a whole year's lighting, and that of the two latter ones for four and one-half months. Considering that all these buoys, which are made of wholly-welded Bessemer plate, on those places where hitherto they have been tested have well maintained their vertical position in the swells; that their light is characteristic, and its power is not surpassed by that of any other light buoys; that the consumption of gas is diminutive and consequently the expense very small; and, lastly, that to judge from the experience up till now the buoys require no caretaking whatever, the opinion of the board is that for the future no trials with light buoys of other kinds are called for, since with this the problem of getting a high sea light buoy in every respect adequate to our requirements is successfully solved."

The pilot director for Finland, under date of Helsingfors, May 15, 1908, certifies as follows:

"Acetone gas lighting (dissolved acetylene) was introduced in Finland by the general pilot and lighthouse board in 1906, when such light, in the flashlight apparatus constructed by Mr. Dalén, was installed in the Edvardsgrund lighted buoy, situated in the Viborg channel, which, during the aforesaid year, burned uninterruptedly one hundred and twenty-six days and nights, and in 1907 one hundred and eighty-one days and nights. Since this test with acetone gaslight turned out so well, it has been installed in Halli lighthouse, in the Gulf of Finland, in the Bolostö buoy, in the channel between Helsingfors and Kotka, and in the new Finnish lightship "Storbrotten." During the present year still another leading light with acetone gas has been erected, and another has been ordered by the general pilot and lighthouse board; and, further-

more, this board has appealed to the imperial senate of Finland for an appropriation of funds for erecting five leading lights with acetone gas. Among other advantages of lighthouses with acetone gas, the cost of caretaking is reduced to the least possible minimum, since when such lighthouse lanterns are once lit they will burn uninterruptedly as long as the gas lasts. The gas supply necessary for each lighthouse can in each case, depending upon circumstances, be regulated by installing a larger or smaller number of accumulators.

"According to experience in regard to acetone lighting thus gained by the general board, this kind of lighting is very suitable for use in lighthouses, and especially such as are located on rocks and reefs which are difficult of access."

## SCIENCE NOTES.

**The National Museum** by arrangement of the Metropolitan Museum of Art of New York will send a representative to Egypt to take part in some excavations now under way there. The Egyptian government is doing some work that will have to be hurried before the waters of the Nile are backed into the big flume basin for irrigation purposes, thus covering an important archæological field which the government wants to explore. The representative of the National Museum will be Dr. Hrdlicka, the anthropologist of the institution.

**A study** of the moisture content of butter in its varying phases is one of the most important problems with which the dairyman has to deal. Investigations along this line have been carried on at the Iowa experiment station for some time, results of which have been published in various bulletins. Bulletin No. 101, on "A Study of the Moisture in Butter," is a continuation of this work. The bulletin is divided into three parts. Part one deals with the relation of the moisture content to the score, and gives the results of extended experiments. In the second part the keeping quality of butter containing varying percentages of moisture is discussed. A large part of this work was done in co-operation with a prominent New York commission firm. The third division takes up "A Method of Control," giving practical directions whereby any ordinarily intelligent creameryman may control the percentage of moisture in his butter to within one per cent.

**At the recent** annual meeting of the Académie des Sciences which was held at Paris, there were a number of prizes awarded for scientific work. Out of 57 prizes which were to be distributed this year, there are only 7 which are not awarded, among these being the Guzman prize of $20,000 for communication with the planet Mars and the Bréant prize for the same amount for a remedy for the Asiatic cholera. Among the prizes awarded this year, the Grand Prix for mathematical science, of $6,000, is divided between Messrs. Bianchi and Guichard for the solution of certain problems, and the Francoeur prize of $200 is given to M. Lemoine for his mathematical work. M. Fredholm, of Stockholm, received the Poncelet prize of $400 for having found new equations. The extraordinary prize of the Marine is divided between Messrs. Dunoyer and Dautriche, who have contributed the most toward increasing the efficacy of the French naval forces. The Plumey prize of $800 for the greatest contribution to steam navigation is awarded to Messrs. Codron, Marchi, Foriant and Le Besnerais. In astronomy, the Janssen prize is given to M. Puiseux of the Paris Observatory for his work in physical astronomy. The principal geographical prize, this being the Tchihatchef prize of $600, is awarded to Lieut.-Col. Bernard for the fixing of the Franco-Siamese frontier. For their work upon the geography of Morocco, Messrs. Gentil, Larras and Traub receive the Gay prize of $300, in common. M. Auguste Chevalier receives the Delande-Guerineau prize for his work upon French Central Africa. In physics, M. Blondel is awarded the Hebert prize of $200, and M. Brillouin the Hughes prize of $500. The important Jecker prize of $2,000, for the author of remarkable work on organic chemistry, is given to Prof. Barbier of the Lyons University. The two Montyon prizes of $500 each for the insalubrious arts are awarded to M. Georges Claude for his work upon liquid air, and to M. Frois. In medicine and surgery the three Montyon prizes of $500 each are awarded to Drs. Valleé and Carré conjointly, Dr. Frouin and Dr. Tissot. The Serres prize of $1,500 is awarded to Dr. Brachet for his anatomical work, while Dr. Lafon receives the $360 Philipeaux prize for his researches on diabetes. Statistical work is represented by the Montyon prizes. M. Deniker of the Museum receives $200, and other less important prizes were awarded in this field. The Estrade-Delcros prize of $1,600 is awarded to M. Hadamard for mathematical work. Regarding the sum of $20,000 placed in the hands of the Academy by Prince Roland Bonaparte, of this amount $5,000 was distributed this year among ten scientists, Messrs. Blaringhem, Estanane, Loisel and others.

## ENGINEERING NOTES.

**Steam shovel records** on the Panama Canal were recently broken by a 95-ton machine which took out 55,419 cubic yards of soft rock at Gorgona in 25 working days. About the same time a 75-ton shovel took out 22,028 yards of earth, and 20,333 yards of rock in 26 days, according to the Canal Record. The former shovel has a 5-yard dipper and the latter a 2½-yard dipper. All shovels are kept under steam for eight hours per day, but are not actually worked during this period steadily owing to the necessity of moving them forward, blasting large stones, and bringing up cars.

**The idea** of the steam turbine, said W. L. R. Emmett, of the steam-turbine department of the General Electric Company, recently, before the Schenectady section of the American Institute of Electrical Engineers, is a very obvious one, and naturally appeals to everybody. It is the simplest form of production of motion from pressure, and was used by the ancients. The whole difficulty has lain in the fact that the velocities to be dealt with were so high. Steam carries so much power and weighs so little that it attains an enormous velocity when its work is turned into motion. In working steam of 175 pounds gage down to 28 inches vacuum, it will impart to itself a velocity of about 4,100 feet per second.

**The United States** Geological Survey is about to establish rescue stations in the principal coal fields of the country, in addition to the experiment station at Pittsburg. These stations will be at or near the greatest centers of accidents, and it will be the purpose of the experts to teach the miners and mine bosses how to use the most approved apparatus for mine rescue work. Government mining engineers thoroughly trained in the use of rescue apparatus will be assigned to stations and will be ready at a moment's notice to go to the scene of any disaster. They will be equipped with oxygen helmets, which will enable them to enter a mine at once, even though it is filled with gas or smoke.

**A series of tests** have been conducted by Prof. Hanisch at Vienna with small concrete blocks in which were imbedded bars of round iron 0.8 inch in diameter. The force needed to draw the bars out of the concrete after six weeks varied from 478 pounds per square inch of surface, for concrete with 304 pounds of cement to the cubic yard, to 656 pounds per square inch of surface of metal in the case of concrete mixed with 910 pounds of cement to the cubic yard of aggregates. In all cases the iron was pulled out with no concrete adhering to it, and none of the blocks were broken or damaged in the operation. Details of the various experiments, with an illustration of the testing machine, are given in the Mitteilungen des k.k. Technologischen Gewerbe-Museums in Wien.—Times (London) Engineering Supplement.

**In a recent issue** of the Mining Journal there appeared a translation of an article by Mr. Ia. M. Pitersky in the (Russian) Gorny Journal, in which a novel method of regulating spouting oil wells is proposed. Briefly, Mr. Pitersky's method consists in sinking a shaft at the top of the well, to a depth equal to about 60 times the diameter of the last series of pipes sunk, this shaft having a diameter of from ten to fifteen times that of the last series of pipes. Near the top of this shaft there enters a pipe connecting with the reservoir. As soon as oil is struck and the oil jet issues under the pressure of the contained gases to a great height, oil is let into the shaft from the reservoir and the height of the jet gradually decreases, until when the top is reached, it has been entirely absorbed, and the flow is even; the oil can then be led to the reservoir along with the gas it contains, thus avoiding the danger and losses incidental to fires.

**Steam engine builders** in Germany have been remarkably successful of late in reducing the coal consumption required to produce a brake horse-power, this being due, no doubt, to the competition of gas and Diesel engines. In the Zeitschrift des Vereines deutscher Ingenieure, Herr E. Josse gives a detailed heat analysis of a "lokomobile," or semi-portable engine, in which the engine, a compound, of 181 brake horse-power, fitted with Lentz poppet valves, is mounted on an internally-fired tubular boiler. This engine operates on steam at 170 pounds gage pressure, superheated 306 deg. F. It requires 10.27 pounds of steam per brake horse-power, which is generated by 1.17 pounds of coal having a calorific value of 14,115 British thermal units per pound. A Wolf "lokomobile," tested in 1905 by Prof. Gutermuth, operating on steam at 168 pounds gage pressure, superheated 260 deg. F. required 11.38 pounds of steam per brake horse-power. According to Mr. F. E. Junge, however, in a recent issue of Power and the Engineer, Prof. Gutermuth has given out figures regarding a 100 brake horse-power Wolf engine, which considerably surpass the foregoing efficiencies. This latter engine consumes but 8.66 pounds of steam and 1.04 pounds of coal per brake horse-power.

## TRADE NOTES AND FORMULÆ.

**Gold Printing Varnish.**—Dissolve in a copper kettle 150 parts of water and 50 parts of soda, heat gradually to the boiling point and then introduce 100 parts of powdered rosin, whereupon it is boiled for two to three hours, or at least until the fluid no longer appears turbid but is perfectly transparent. It is then allowed to cool, poured off, the tough brown rosin soap settled on the bottom of the kettle and to it 100 parts of water and 15 parts of steeped glue are added, heating until the latter is completely dissolved.

**Gum Soulution that is Elastic and Non-Drying.**—93 parts of gum Arabic, 8 parts of soft (barrel) soap, 3 parts of glycerin, 1 part of salicylic acid; the latter is dissolved in 20 parts of alcohol, then the glycerin and finally the soft soap are added. The gum is dissolved in sufficient water to produce a syrup-like fluid and added to the first solution. The solution keeps well and in addition to notable elasticity is powerfully adhesive.

**Artificial Fruit Jelly Extract.**—According to Töller, place in separate paper bags, 18 parts of medium, finely pulverized gelatine, 3 parts of citric acid, also, in a glass bottle, a mixture of 1 part of any desired fruit ether, 1 part spirits of wine and dissolve in the mixture, for the purpose of producing the desired color, 0.1 part of raspberry red, or 0.1 part of lemon yellow, or 0.1 part of non-poisonous aniline green. When using, dissolve the gelatine and citric acid in boiling water, add 125 parts of sugar, and before it cools, mix it with the fruit ether mixture.

**A Good Finish for Curtains.**—One part each of wheat starch, corn starch, and good white talcum are mixed together. First the starch is mixed with a little water into a thick paste, so that all the starch lumps are reduced. Then the requisite quantity of water is added, and, constantly stirring, the talcum. This mixture is allowed to boil up for a short time, water is added until the proper dilution is obtained, and the curtains are immersed in this finish while it is as hot as possible. The talcum, of course, is not dissolved in the water, but it is held by the starch and is mechanically attached by it to the fabric, and the curtains thereby attain the weight and appearance of new.

**Floor Stain.**—Boil out 250 parts, by weight, of fustic and 120 parts of Brazil wood with 24,000 parts of soap-maker's lye and 120 parts of potash, until the fluid amounts to 12,000 parts. In the decanted solution, allow 30 parts of annatto and 750 parts of wax to dissolve under the influence of heat, and stir until it is cold. This gives us (counting 1,000 parts for 1 kilo or 2 pounds) 9 to 10 bottles of brown red stain, sufficient to keep a large room in condition for a year. The floor should be swept daily with a bristle broom, wiped up twice a week with a fairly moistened cloth, then in part, where there is much traffic, coated with stain and scrubbed in with a hard brush. Every four weeks, the entire floor is painted over with stain by means of a brush and brushed at once.

**Fruit Juices, Their Rational Production.**—The ripe fruits (raspberries, strawberries, currants, or cherries) are first mashed, and in the case of the latter, the pits crushed. In suitable stone jars, they are then allowed to undergo fermentation, with an addition of ¾ pound of sugar to 50 pounds of fruit mass, at a temperature of 68 deg. to 73 deg. F. Constant heat and sugar play an important part in this process; the first promotes the growth of the fermentation fungi and the latter is split up into carbonic acid and alcohol, which separates the slimy substance (pectine) and prevents the formation of mold on the filtrate. After four to five days, a clear juice is obtained, which must be mixed once a day, with the aid of a wooden spoon, with the pulp that is forced to the surface by the carbonic acid. The juice obtained by pressing, which must under no circumstances be allowed to come in contact with iron or tin, the elements of which at once decompose the coloring matter, is boiled, with the above quoted proportion of sugar and the finished juice is drawn, as hot as practicable, into suitable bottles. By this means, a certain sterilization is effected. The microorganisms are more or less killed off by the heat and their action, during the storage period, is prevented.

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